Master's Thesis

Shared Autonomous Vehicles: User Expectations and Opportunities for Design

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ABSTRACT

With radical technological developments, we will soon experience self-driving mobility services of the future. Early autonomous vehicles were only able to recognize and handle some driving situations, but the continuous development of technology eliminated this boundary. Recent studies expect fully autonomous vehicles to be introduced as Shared Autonomous Vehicle (SAV), a shared-fleet service model. In addition, many researchers expect that using SAV, which is a form of shared automation vehicles, will create socio-economic benefits such as preventing urban sprawl, improving safety, reducing emissions, and creating more free time. However, a recent study has shown that most current SAV models focus on optimizing system-wide operations rather than on the user side. The research related to this issue has expressed concern that technologies such as SAV could fail without considering user-side experience. As a result, research and development on the user side of SAV, which provides many socio-economic benefits, is needed.

Therefore, this study aims to identify design opportunities that provide the best user experience in SAV. In addition, suggested design opportunities aim to contribute to future SAV design by identifying design elements that encourage and support future users' in-vehicle activities. To find out user experience and needs in SAV, I considered in-vehicle activities due to automation as an important user factor and considered mood as a way to support design approaches based on user needs. In this regard, considering that SAV is likely to be operated in metropolitan areas, three major trip types of SAV were selected through literature review: commute, business, and leisure. Then, Experience prototyping and self-report measure design methods were applied to explore specific user experiences for selected trip types. Finally, based on the results of the first study, a designer workshop was conducted to find user-side design opportunities that encouraged future use of SAVs.

As a result, this study provides data on specific user experiences such as in-vehicle activity, desired mood, and user’s needs of future passengers, while at the same time providing four design opportunities to provide the best possible experience for SAV users. Furthermore, a visual example of applying four design opportunities to three main trip types through user data is also provided.

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1. Introduction

1.1. Research background

With fast-growing technology, we will soon be able to experience autonomous vehicles driving themselves to destinations. Autonomous vehicles (AV) provide a wide range of benefits in terms of safety, efficiency, environmental impact, and improved mobility because it collects information about all road traffic conditions in real-time. The autonomous vehicle was first unveiled by Google (now Waymo) in 2012 and has received much attention from the public, media, and transportation researchers. The explosive increase in interest in AVs is due to the many opportunities and benefits this technology brings. The UK's Department for Transport (DfT) identified some benefits from autonomous vehicles: (1) improving safety; (2) preventing road traffic congestion; (3) reducing emissions; and (4) creating more free time (inside the vehicle).

For decades, Autonomous vehicle technology has been a simple conceptual idea. However, improved artificial intelligence and real-time data processing technologies have enabled the practical development of AV. Early AV was only able to recognize and handle some driving situations, but with continuous technological development, this limitation has been removed (J. Lee et al., 2019). As boundaries of AV technology have been removed, radical development has been made beyond the range of existing autonomous vehicles, and several researchers have predicted that various types of AV services will appear in the future (Wachenfeld et al., 2016). However, it is difficult for individuals to own AVs in terms of price because AVs are equipped with many advanced technologies. Therefore, researchers and analysts believe that the first fully autonomous vehicles will be introduced to the public market in the form of a shared-fleet service model (Bansal & Kockelman, 2018; S. Shaheen & Cohen, 2019). This concept is a type of service that shares autonomous vehicles, and this service can replace private conventional vehicles (PCV) (Milakis et al., 2017).

The concept of shared autonomous vehicle (SAV) combining existing vehicle sharing and taxi service elements with AV refers to public transportation using automation technologies (Fagnant et al., 2015). These services can provide low cost and high accessibility through mobile on-demand services (Burns, 2013). In recent literature based on autonomous vehicles, the SAV of public transport operations has been convincingly argued as a solution to the individual ownership problem of PCV (Fagnant & Kockelman, 2018; Loeb et al., 2018; Vosooghi et al., 2019). Simulations across Berlin's Lisbon and Austin regions have shown that one SAV can replace the demand for 10 PCVs (Bischoff & Maciejewski, 2016; Fagnant & Kockelman, 2018; OECD, 2015). This service is much cheaper than using PCVs in terms of cost and is expected to solve chronic traffic congestion in urban areas.

Mobility is an important prerequisite for social, cultural, economic development and social participation. And the advent of fully autonomous automotive technology will create a new paradigm for mobility systems. Researchers argue that SAV technology, which brings many socio-economic benefits considering urban mobility, should be adopted early (Hörl et al., 2019; Winter et al., 2018). However, most of the current SAV models focused on optimizing system-wide operational costs (e.g., vehicle mileage, fleet size, travel time, etc.), while less attention is paid to considering traveler-centered aspects such as privacy, comfort, waiting time, and others in the SAV model (Maghraoui et al., 2020). In addition, the related literature has repeatedly expressed concerns that technologies such as SAVs could fail if the reliability of the technology, novelty of the technology, and lack of user experience (Kyriakidis et al., 2015; Schoettle & Sivak, 2014). Therefore, research on the user side and user experience for technology acceptance should be developed.

A major investment in existing transportation systems was to provide comfortable services to reduce private vehicle usage. However, existing public transportation did not provide services comparable to private vehicles. Instead, existing public transportation focused on accommodating many people and dropping them off at their destination. In addition, travel time can be considered a 'cost' by people. People do various 'personal activities' to use their time productively and effectively while using transportation. However, people are not guaranteed personal activities because private vehicles have driving tasks, and public transport is crowded with many people. Therefore, encouraging and assisting in-vehicle user activity can be an important factor in encouraging users to adopt new technologies.

Mood is considered as a way to explore the experience of overall user activity, such as user emotional states and demands arising in a particular space (shared environment). To better understand how users adopt innovative immersive technologies over the long term, it is essential to know how technology affects users' moods and how these moods affect user-technology interactions (Desmet et al., 2016). Mood, which functions as a human-centered foundation, is ideal for supporting current technology-driven and intuitive-based design approaches. In addition, mood can affect important aspects of behavior, such as the beginning, intensity, persistence (Geen, 1995).

Based on these issues, this study aims to view user activity as an important factor and propose design opportunities that provide the best experience for users' activities in shared autonomous vehicles (SAV) through moods. For this, I examine user activities in detail to investigate user priority activities, needs, and expectations by three trip types of SAVs. The results of this study are as follows. (1) detailed user-side needs for SAV, (2) desired mood for each activity, and (3) priority activities for each trip type. Finally, I provide detailed design opportunities and methods that can be applied to SAVs based on the overall outcomes.

1.2. Research questions

To achieve the objectives of this study, two main research questions, and three background research questions are formulated. The main questions are:

- What is the design opportunity to provide the best experience for the user activity in SAV?

The background research questions are as below:

- What activity do users usually do in SAV?
- What wishes and expectations do future users have for SAV?

1.3. Research framework

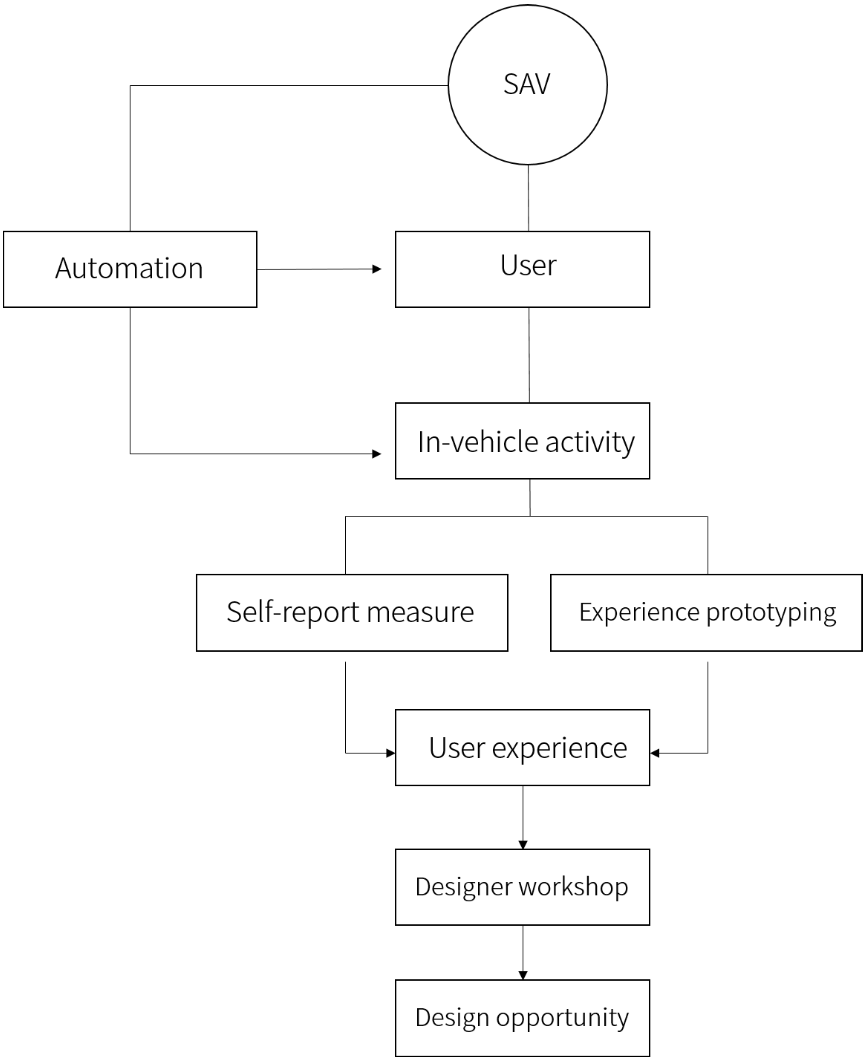


Figure 1. Model of study for achieving research goals in SAV

2

Theoretical background of research

- Introduction
- Shared Autonomous Vehicles
- In-vehicle activity
- Mood

2. Theoretical background of research

2.1. Introduction

Continuous development centered around urban led to the expansion of urban areas. The Urban Sprawl occurs when residents of the suburbs around the city use private cars to commute to developed urban areas (Vuchic, 2007). The limited supply of urban areas and environmental excesses is causing traffic congestion over traffic capacity, extending the travel time of drivers and passengers using the road (Rudnicki et al, 2007).

Figure 2. Traffic congestion in LA

The United Nations reports that 54% of the world's population resided in urban areas in 2014, and estimates that by 2050, the proportion will increase by 12% to 66%. This trend of increasing urbanization is putting tension on already congested urban roadways. According to report, traffic congestion wasted 8 billion hours a year in the U.S. in 2015 (Inrix Technology, Inc 2015). In addition, most vehicles in urban areas emit significant amounts of harmful chemicals and fumes into the air which negatively affects the environment (Wesołowski, 2003). As an alternative to the problem, increasing the utilization rate of public transport for suburban residents is most effective. However, the current public transportation is not providing as good a service as passengers are paying high costs.

One of the promising concepts and ideas that can reduce the negative impact on the availability of existing public transportation is implementing electric, shared autonomous vehicles (SAEV) in the urban environment. Many people believe that the spread of AVs can affect the fundamental urban structure of cities. Automated vehicles (AVs) are vehicles used to move passengers or freight. It aims to support or replace human control. AVs are being developed for use on public roads. If AVs start to be used on public roads, it can solve traffic congestions and environmental problems while also eliminating the causes of human traffic accidents. In addition, AVs can provide users with additional time and productive personal activities, given that users no longer need to pay full attention to driving (OECD, 2015)

The potential of AV technology is expected to have a significant impact on mobility services in the future. AV technologies include advanced technologies such as 3D cameras, advanced GPS, pattern recognition software, mechanical vision, light detection, range (LIDAR), etc. (OECD, 2015). In this regard, more than 30 companies around the world developed AV technology in 2016 (CB Insight, 2016), including major car manufacturers and many leading technology companies, including Toyota, Tesla, Google, and Uber. Moreover, most car manufacturers that announced their AV plans have already released some automated vehicles in 2017. The motivation for this global technology development is the safety consequences that can be relieved by autonomous vehicles. The National Highway Traffic Safety Administration (NHTSA, 2008) reported that 93% of crashes between 2005 and 2007 were human caused. Car deaths in the US increased by 8% from 2014 to 2015, and this rate increased until the first half of 2016 (National Safety Council, 2016). In this regard, (OECD, 2015) reported that if AV takes charge of driving tasks instead of humans, the accident rate could fall by 80% to 90%. However, some experts estimate that Level 4 AV technology is expected to become cheaper over time (A. Davies, 2015), but it is still very expensive. Therefore, SAV, a service that shares autonomous vehicles with multiple people, has recently emerged. At this point, the high cost of initial AVs is a hindrance to entering the fully autonomous vehicle market, while the market potential for SAV services is growing.

2.2. Shared Autonomous Vehicles

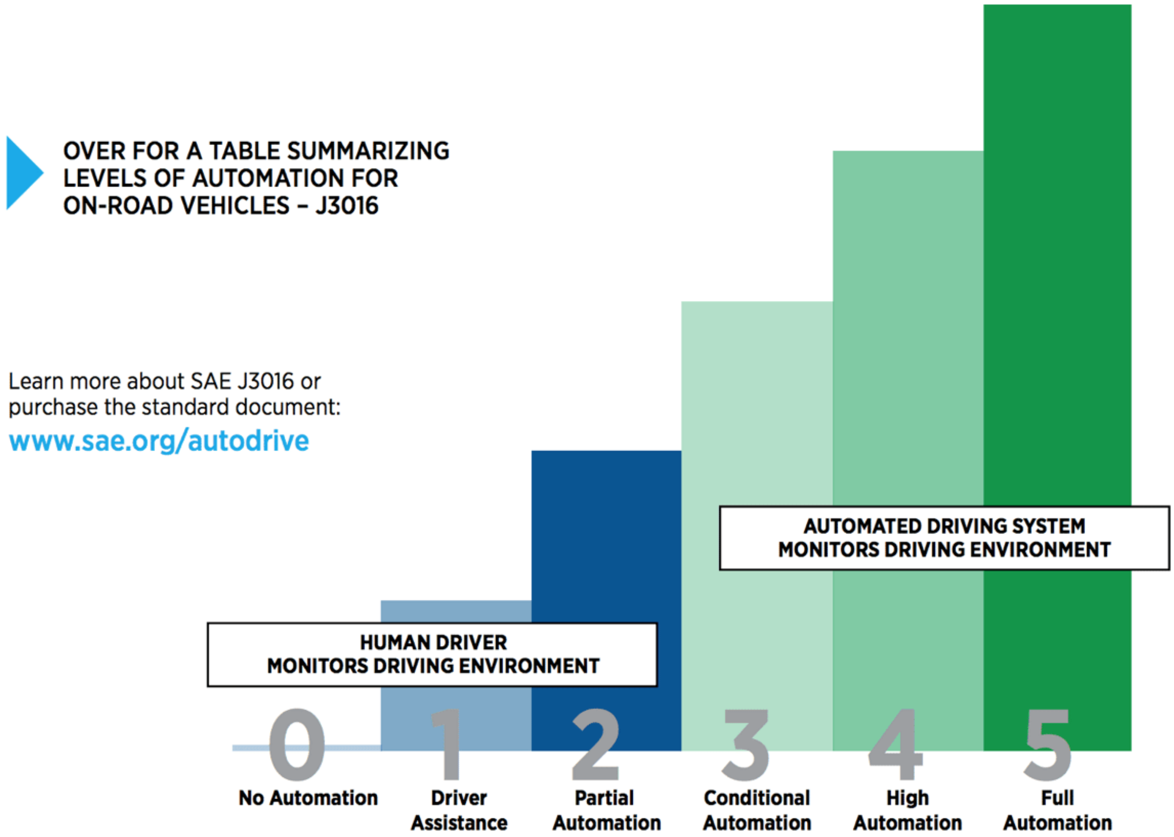


Figure 3. Levels of driving automation. Source: SAE International

Understanding what autonomous driving means is desirable to understand the context of SAVs. The above Figure 3 provides information on six levels of autonomous driving (six steps in total from 0 to 5) classified by SAE international in 2016. Level 0 means no autonomous driving technology in the non-automation stage, where the driver must be responsible for both driving and speed control of the vehicle. Level 1 is the driver's assistant. Level 1 includes the ability of the system to control the speed and braking of the vehicle and maintain a constant speed. Level 2 is partial automation. At this stage, the system simultaneously controls the speed and direction of the car without the need for driver intervention. However, the subject of driving is still the driver. Level 3 is conditional automation. At this stage, where driver intervention is further reduced, the system requests the driver's operation if an unexpected situation occurs and the autonomous driving mode is released. From level 3, the system can overtake the car in front of it or detect obstacles and avoid them. Level 4 is a highly automated stage. Like Level 3, the system performs full driving, but the difference is that the system must respond safely to hazardous situations. Therefore, this Level is self-controls safety-related functions. Level 5 is a fully automated step. SAV corresponds to level 5(Full automation) of autonomous driving. From level 5, one can think of a fully autonomous vehicle that removes driver intervention. In other words, when a passenger selects a destination, the system decides and drives itself without human intervention.

SAVs as part of a shared fleet may include benefits such as affordability, high efficiency, low emissions, and small size (Greenblatt & Shaheen, 2015). Shared mobility is sharing vehicles and other slow modes, allowing users to access transportation mode as needed**.** Shared mobility includes car sharing, ride sharing, on-demand ride services. Shared mobility services such as Lyft and Uber have grown rapidly worldwide, and the global car sharing market has 4.8 million members (OECD, 2015). The growth of AV technology and shared mobility services can provide alternatives to address the chronic problems of conventional transportation. In addition, it has the potential to change the way urban environments and people lifestyle. As innovations in these systems converge, many automakers are researching, investing in, or acquiring mobility and related technology companies.

Figure 4. Cruise: Shared autonomous vehicles concept model. Source: origin

Car sharing, which typically allows flexibility in using a private car without the obligation associated with ownership, was considered a flexible mobility option (S. A. Shaheen & Cohen, 2012). As such, car sharing, which facilitates multi-modal travel behavior (Nobis, 2006), can facilitate sustainable mobility and lowers the level of private car ownership (Firnkorn & Müller, 2012; Martin et al., 2011), In addition, the introduction of automation technology makes car sharing services more accessible and affordable. Because automation technology will accommodate their passengers directly at their origin, home and they no longer have to worry about walking distance access to the car. Therefore, the AV technology could reduce the costs of providing one-way car sharing services and resolve the relocation issues of one-way car sharing (Firnkorn & Müller, 2015).

In the commercialization level of technology, several studies on AVs and results of road tests have been reported (Anderson et al., 2014; Basulto, 2013; Lavrinc, 2013). In addition, most of the car companies we know, such as Honda, Nissan, Ford, Hyundai, Volvo, Daimler, BMW, and Fiat-Chrysler, will develop autonomous vehicles and have plans to release full-automation vehicles (i.e., vehicles that can drive without any human intervention) starting in 2021 (Walker, 2018). Furthermore, in December 2020, start-up ZOOX, acquired by Amazon, unveiled its first self-driving taxi. The Robo-taxi is a four-seater (4-fleet size), can travel 16 hours on a single charge and has a maximum speed of 75miles (120km). ZOOX is taking driving tests in Las Vegas, Nevada, California, and San Francisco. In addition, it plans to launch its first commercial service in San Francisco and Las Vegas through on-demand services. In addition, Apple also expressed its intention to participate in the autonomous vehicle market in 2021, proving that the AVs market is a future competitive market. In this regard, public institutions have also begun to think about the possibility of dealing with SAV services, and to explore how to properly regulate or operate these services.

Autonomous mobility on-demand services

Private automobiles that now dominate roads are inadequate and unsustainable for the future of personal urban mobility. Private automobiles have led the paradigm of personal mobility by enabling fast and convenient point-to-point travel within cities. However, this paradigm is challenged due to a combination of factors such as tailpipe production of greenhouse gases, ever-increasing demands on urban land for parking spaces, reduced throughput caused by congestion, and dependency on oil (Mitchell et al., 2010). The rapid increase in urban population is due to combined impacts such as rapid urban development and increased car ownership in developing countries. In the US, urban vehicles account for more than half of all oil consumption sectors (US EIA, 2013) and producing 20% of total carbon dioxide emissions (UNEP, 2013). In 2011, congestion in metropolitan areas increased urban Americans' travel times by 5.5 billion hours, and this figure is projected to increase by 50% by 2020 (Texas A&M Transportation Institute, 2019). In addition, more than 90% of cars are parked without driving (Federal Highway Administration, 2010). Parking issues cause additional traffic congestion (parking on the road's shoulder) and worsen the traffic congestion problem by occupying the land for a certain time. To address this problem, one of the most promising ideas for the mobility of future urban environments is the concept of vehicle sharing using Autonomous Mobility-on-Demand services (AMoD).

Mobility-on-Demand (MOD), as defined by the US Department of Transportation, is a new concept based on the principles of commodities where other attributes such as cost, delay time, travel time, and many connections have distinguishable economic value in the concept of transportation. MOD enables consumers to easily access mobility and services on demand by dispatching or using shared mobility and public transportation solutions through an integrated and connected multi-modal network. The most advanced form of MOD passenger service is the integration of travel planning and booking, real-time information and fare payment into a single user interface.

Figure 5. Integration of existing public transportation services through mobile applications

Passenger modes promoted through MOD include car sharing, ride sharing, bike sharing, shuttle services, public transport, and other transportation solutions. Furthermore, given that all passengers using transportation mode have a personal purpose, they can use their time more efficiently and productively through this service. Therefore, Autonomous mobility on-demand service, which combines mobile on-demand systems with autonomous driving, is attracting significant attention as an excellent service that enables SAV operation.

Relevant literature discussed the operational and economic aspects of the Autonomous Mobility on Demand service (AMOD) system, a transport mode that combines autonomous vehicles and MOD services (Pavone, 2015). another study reported that combining MOD services in SAV user environments would provide more flexibility than conventional public transportation or shared services (Stocker & Shaheen, 2019).

AMoD, which combines AV technology and MoD service, utilizes a variety of supporting transmission services through smartphones to deliver vehicles to passengers based on comprehensive data on user needs. This service is also a function of predicting changing demand in real time, and makes it convenient to build a DRS system of passengers. Dynamic ride sharing (DRS) refers to real-time matching of travelers with similar destinations and schedules, allowing them to travel together and share costs (Agatz et al., 2012; Amey et al., 2011; A. Lee & Savelsbergh, 2015). The system allows a certain number of travelers to be transported in a small number of vehicles, which could increase the efficiency of urban transportation and potentially reduce environmental pollution and traffic congestion during peak periods. Moreover, it enables riders in a vehicle share expenses, providing substantial savings, typically for day-to-day commutes. At this point, this combination of DRS and MOD is particularly suitable for Shared Autonomous Vehicles (SAVs), and could provide inexpensive mobility, eliminating the need for private conventional vehicles (Levin et al., 2017). Therefore, In the future, transportation systems will be a mixed system of regular vehicles (RVs) and SAVs.

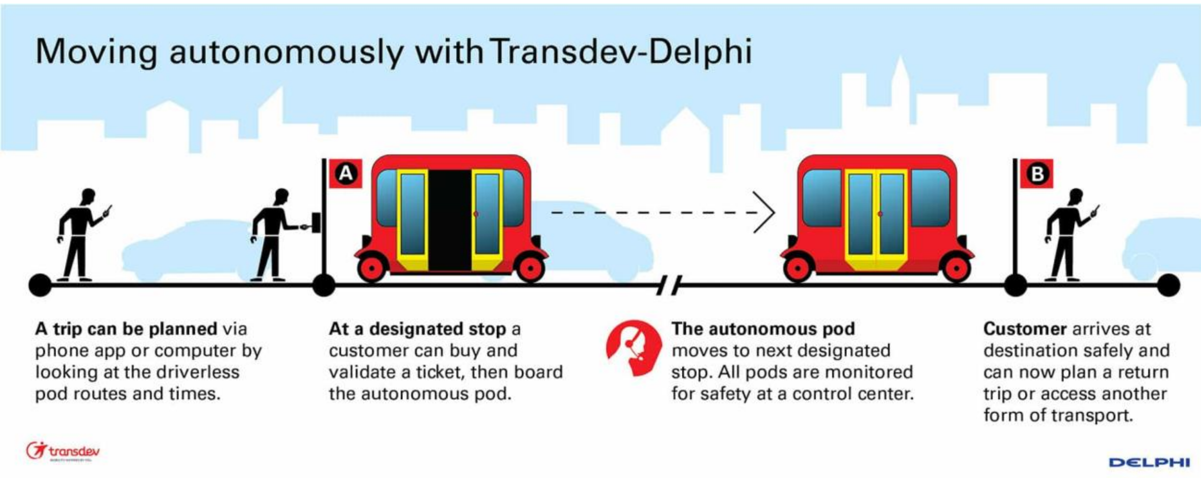


Figure 6. Transdev-Delphi Partnership: Scenario of AMoD systems to develop fully autonomous vehicles.

AMOD's usage scenarios are as follows. (1) MOD providers use passenger information to collect data for grouping passengers from similar origins to similar destinations. (2) When all passengers are gathered, the waiting time is calculated and sent to the passengers. (3) The vehicle moves on its own to pick up the nearest passenger near the vehicle. 4) When all passengers are picked up, the vehicle starts driving toward its destination. (5) Passengers arrive at their destination, and the vehicle finds another passenger through the AMOD system. In this part, the vehicle does not have to run on the road again, nor does it occupy parking space. Therefore, the composition of these systems is highly appropriate for urban traffic environments and is expected to have a positive impact on high-traffic urban environments.

MOD systems have been argued as a key element for sustainable personal urban mobility in the 21st century(Mitchell et al., 2010). In addition, the Autonomous Mobility-on-demand service will easily solve the first/last mile problem for passengers to board their vehicles in autonomous vehicles. It will help many people in the city access SAVs.

Travel cost and fares

The economic benefits of SAV focused on travel costs have been convincingly argued in several studies (Chen et al., 2016; Chen & Kockelman, 2016; Fagnant & Kockelman, 2018; Loeb et al., 2018). As a case in point, the general taxi fare consists of almost 50% of the driver's wages. In this regard, SAV, operated under the concept of driverless and public ownership, will be a cheaper transportation service and will replace a significant proportion of conventional vehicles (Levin, 2017). This is because SAV has the ability to handle the same or higher demand with fewer vehicles, and the DRS system allows many passengers to distribute the cost required to use the vehicle.

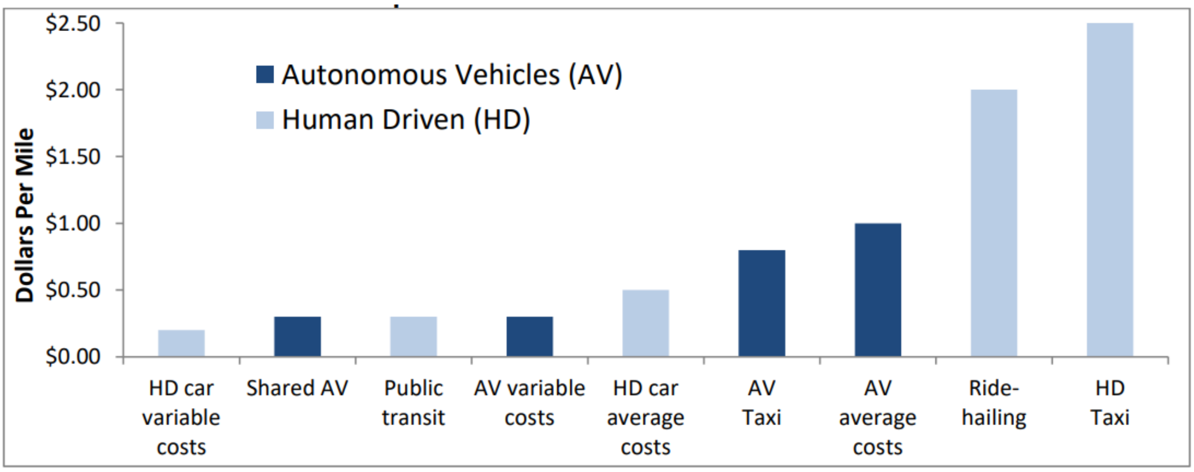


Figure 7. Cost comparison by operation mode (Litman, 2020)

Figure 7 provides information comparing the cost of transit operating modes. Moreover, Shared AV is expected to operate at a similar cost to public transit. For detailed SAV costs, refer to Figure 7. The table presents two categories of autonomous vehicles (AV) and human driven (HD). The table results indicate that shared AVs will operate at approximately the same cost as existing public transportation costs. AV Taxis are more expensive than Shared AV. This shows that there is a significant price difference between the way in which multiple people pay and the way in which the cost is paid alone.

According to the table, Shared AV costs are estimated at approximately $0.3 per person and AV Taxi at approximately $0.9. if this happens, SAV will be about three times cheaper than AV Taxi in terms of cost. Accordingly, SAV and AV taxis are considerably cheaper than human-driven taxis but shared AVs are expected to attract people through lower prices. Furthermore, the addition of elements such as advertising and promotion to SAVs may be available at a lower cost than estimated. In this respect, a prior study expressed the possibility that SAVs could be provided to passengers free of cost through the entertainment and advertising industries (Arbib & Seba, 2017). Therefore, SAVs can operate at reasonable prices and will become cheaper if various services are integrated.

SAV fleet size

Today's experimental SAV service is a modified version of ordinary electric vehicles with four or five seats inside. However, it is uncertain whether these vehicle designs will be the most efficient designs for future urban driving considering SAV service features (AMoD, DRS). According to literature (Vosooghi et al., 2019), some configurational characteristics, such as fleet size and service area, allocation and relocation strategies and infrastructure, directly affect the parameters critical to travelers' mode choice decision. In this regard, in-depth investigations have recently been conducted on SAV fleet optimization, cost structures of operational models, and rebalancing (Bösch et al., 2018; Hörl et al., 2019; Loeb & Kockelman, 2019). Therefore, I conducted a related literature review to identify the SAV fleet size suitable for urban environments.

(Heilig et al., 2017) used an agent-based travel demand model with traffic simulations to evaluate transportation systems in which AMOD services replace all private cars in the Stuttgart area. (Liu et al., 2017) used a simulation framework to simulate a fleet of SAVs integrated into a road network of Austin, Texas. All prior studies tried to consider the overall factors of services operation of SAV to determine the required fleet size. The results showed that in SAV environments, fleet size affects overall aspects of services such as cost, waiting time, allocation, and relocation strategy.

Among them, a simulation study based on Rouen Normandy metropolitan area in France, a promising candidate where private modes are likely to be replaced by SAV services, has been conducted (Vosooghi et al., 2019). They produced accurate outputs through a population (approximately 500,000 residents) and metropolitan network size to apply the simulation results to future SAV service designs. Simulation results found that the optimal fleet sizes for the individual ride and ride sharing services are different by comparing fleet usage with the empty distance ratio. Furthermore, they report that the best performance fleet size in the ride sharing scenario is between 2.5K and 3.5K vehicles and that the fleet of standard 4-seats 3.0K vehicles can be the best performance option for ride sharing. In conclusion, they indicated that the optimal seating configuration for implementing SAV-like systems in urban environments is four-seater, and benefits may be limited for four-seater or more.

In the literature review, many researchers mentioned important user-side points, indicating that additional seats and capacity can potentially affect user-friendly cognition and that these factors can affect user choice in real-world operations of SAVs. At this point, the SAV fleet size may require extra vehicle capacity in terms of seats or luggage compartments. In addition, providing additional space and services for entertainment, education, and business purposes while using SAV services can lead to better passenger experiences.

2.2.1. *Relation of SAVs to public transportation*

AV can promote the growth of shared mobility services, and shared mobility services can make the operation of autonomous vehicle system financially possible (Gurumurthy & Kockelman, 2018; Stocker & Shaheen, 2019). This possibility can lead to a more sustainable future by improving mobility when integrated with public transportation systems (UITP, 2017). if AV technology becomes public transportation through a shared AV service, the socio-economic advantages are the greatest. Specifically, SAV could supplement the PT network by reducing walking distance and personal time for users to use public transportation and providing operational services accessible to various routes they want, and activating SAV ride sharing behavior can effectively reduce traffic congestion indicators and individual travel costs.

The adopting of SAV poses a significant threat to existing public transport systems. A study to explore how autonomous vehicles can reshape the future of urban mobility concludes that the introduction of SAV services will replace both public transportation and private car use in urban areas (World Economic Forum, 2018). In existing public transportation use scenarios, passengers had to change their routes several times to transfer, and when they got off, they wasted time walking to their destination. However, Once SAV is introduced as a public transportation system, passengers will no longer need to change routes to transfer, and will no longer need walking distance. In addition, comfortable seating during travel time is guaranteed, and the time to reach the final destination is freely available. Eventually, SAV systems, which are more convenient and have higher accessibility than conventional public transportation, can replace existing public transportation while providing a higher level of user experience. additionally, SAV can be seen as a means of continuous public transportation that increases the attractiveness of travel by providing the first/last mile service.

Because the adoption of SAV complements the problems of existing public transportation, it can have a positive impact on travel behavior and the way people move and increase system convenience for passengers. Therefore, AV and SAV-related studies highly value integrated PT-SAV systems and focus on the system aspects for public transportation of SAVs.

I suggest a table (see Table 1) that classifies the features of SAV and existing public transportation, providing the characteristics and differences between SAV and public transport. Each characteristic can be easily understood through this picture.

Table 1. Differences between existing transportation and SAV in urban environment

Category	SAV	TAXI	BUS	SUBWAY
How to use	On-demand Direct boarding (AMOD)	Direct boarding	Waiting & boarding	Waiting & boarding
Purpose	High-convenient efficiency and middle accommodation	High accessibility and small accommodation	High efficiency and large accommodation	High efficiency and large accommodation
Capacity	4 to 10 people	1 to 4 people	1 to 50 people	1 to 300 (one space standard :108) (Maximum : 300)
Space Size	Middle (Varies by vehicle)	Small	Large	Roomy
Cost	Inexpensive \$0.30/km, \$0.9/3km (Approximately)	Very expensive 3km = \$12~\$16	Inexpensive 3km = \$1.75	Inexpensive 3km = \$1.75
Travel time	Short (Real-time road conditions)	Short (Shortest route operation)	Long (Stop on each line)	Long (Stop on each line and needed transfer)
Route	Direct Drop (From departure to arrival destination)	Direct Drop (From departure to arrival destination)	Pre-defined routes (on fixed)	Pre-defined routes (on fixed)

The SAV service cost predicted in the several literatures ranges from \$0.11/km to \$1.03/km, with a prominent range of \$0.19/km to \$0.30/km (Bauer et al., 2018; Chen et al., 2016; Keeney, 2017; Walker & Marchau, 2017). In a paper showing various cost comparisons between AV and Human Driven, they predict that the cost of a shared AV would be approximately \$0.35/km (D. Lee, 2020). In addition, other categories of public transportation costs are based on Los Angeles (Metropolitan) costs and it was based on the 3km. The travel time reflects the fact that SAVs do not stop at transfers or fixed routes, although there is a waiting time to pick up passengers.

In Table 1, comparing traffic modes and SAVs, SAVs show distinct advantages across all categories. In particular, in terms of cost, SAV is much cheaper than existing public transport (about twice as much). Moreover, considering that SAV does not need to stop or transfer like buses or subways and that the travel time is short due to direct destination drop-off, it can be clearly seen that SAV is a service that can replace existing public transportation. In addition, passengers can be provided with a more comfortable travel and pleasant environment because SAV does not have to accommodate many people, such as buses and subways (except taxis).

The positive impact of the size of the economy, which is determined when SAV becomes public transport, is clear. According to a comprehensive study covering the literature of overall SAV services, they expressed that technology adoption such as SAVs should be promoted earlier to achieve the benefits of urban mobility (Narayanan et al., 2020).

2.2.2. Major trip type in SAV

For users, transportation is used to achieve individual objectives. Existing public transportation created routes and circulated fixed lines to meet the objectives of many passengers as possible. The important point is that the purpose of passengers using transportation varies from person to person. it is important to find out which trip-type mode the SAV can operate in order to replace the role of existing vehicles and public transportation. Therefore, I conducted a literature review to find out what travel modes SAV adoption can support in urban areas.

Before identifying the major trip types, it is desirable to understand that the appropriate place to take full advantage of the adoption benefits of SAVs is metropolitan areas. Some of the aforementioned problems (e.g., urban sprawl, vehicle accidents, environmental problems) occur frequently in urban environments. Indeed, to address these issues, SAV focuses on replacing public transportation in urban areas.

Researchers believe that existing public transport passengers, Individuals with flexible schedules, and city residents are likely to ride-share SAVs for commuting and long-distance travel (Gurumurthy & Kockelman, 2020; Wang & Akar, 2019). In the case of commuting, commuting using SAV can be quite attractive for city dwellers without vehicles. Because SAVs can arrive at the time and place they want, so passengers don't have to worry about missing the vehicle. Also, passengers will experience a shift from an annoying and crowded environment to a pleasant environment. In particular, SAEVs are suited to the high demand for long-distance daily commuting due to low maintenance requirements and low-cost energy (Golbabaei et al., 2020). In the case of leisure, SAVs can provide reasonable and productive travel for passengers in suburban areas where rail and bus lines are scarce or for modern people who value personal leisure. The other case is business trips. Some SAV users may prefer to handle their work while boarding time to reduce working hours in the office (Krueger et al., 2016). In addition, the advantage of no stops and transfers can give office walkers a positive cognition.

Results from the literature review suggest that SAVs in urban areas will be dominated by three modes of travel: commuting, business, and leisure.

2.3. In-vehicle activity

In the literature on transportation economics and evaluation, travel time in a vehicle is considered to produce disutility (Mokhtarian & Salomon, 2001). For travelers, the loss of time on the move is 'cost', which is considered in the user's transport evaluation and mode selection decisions. However, autonomous vehicles are expected to enable travelers to engage in other valuable activities during travel time, thus securing 'free time'. In a report dealing with the value of autonomous driving, researchers estimate that the economic benefits of using time productively depending on autonomous driving technology could be up to £20 billion in the UK (KPMG, 2015).

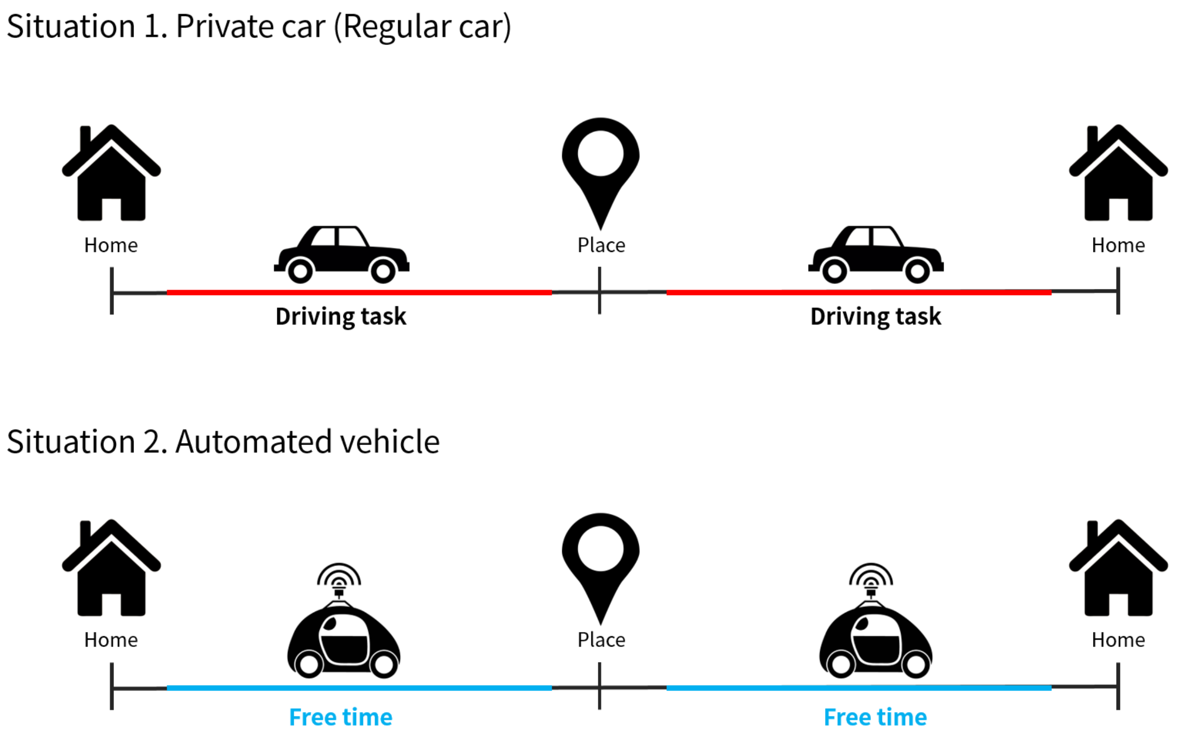


Figure 8. Private cars have driving tasks, while AV or SAV do not have driving tasks, allowing passenger to use free time during travel.

Regular vehicles have a default attribute called 'driving'. In the case of personal vehicles, driving tasks occur, which can lead to wasted travel time. On the other hand, there is no driving task in the case of automated vehicles, allowing existing drivers to switch to passengers and use travel time productively. These situations can be applied to all cases related to distance movement.

Nearly all of the literature on the use of in-vehicle travel time has recently focused on public transport (Keseru & Macharis, 2018). Most vehicle trips for commuting in developed countries are single occupancy, and travelers are given a driving task. The task of driving always requires the driver's attention, limiting the driver's opportunity to engage in other useful activities (except for passive activities such as listening to radio/music) during travel time (Wadud & Huda, 2019). The related paper describes the time spent on a trip as a source of disutility for two typical reasons: first, the act of traveling itself could cause fatigue and stress for drivers; second, travel time is a 'waste' or 'loss' that could be spent doing other valuable activities (Ettema & Verschuren, 2007). Most people want to use their time productively. This intention is the same when driving or using traffic. Listening to radio or music while driving may be relaxation or diversion, but doing other activities at the same time as driving tasks can be seen as an effort to create productive time.

Using public transport and using private vehicles always requires compromise. Private cars provide freedom and comfort, but drivers cannot make productive use of driving time. Conversely, public transportation can lead to productive and efficient use of travel time, but it causes a lot of inconvenience in transferring and sharing space with others. However, SAV could change this compromise. This reason is that removing driving tasks creates opportunities to engage in productive time and activities.

2.4. Mood

We are always in the ‘Mood’. Awareness of affective tendencies, such as mood, can be felt in any situation, event, or even unwanted, if not long-lasting. These represent a non-reflective feeling state that forms a key component of our affective being (Russell, 2003). The most significant feature of the mood is that it influences our evaluation of behavior, motivation, and daily interactions (Kelley & Hoffman, 1997). when in a good mood, people are open to new ideas, and creative. This tendency can be easily agreed upon in everyone's experience of the mood.

Recently, the mood can be easily explored in various design fields such as product design, interactive technology, and service design. When in a good mood, people evaluate life as satisfying and fulfilling and tend to remember more experiences and memories that were positive or good in life than when they felt bad (Forgas & Bower, 1987; Kahneman et al., 1999). Accordingly, Research that utilizes the mood itself as a material to induce people's actions to help develop products or increase development efficiency continues to be used. Especially, the mood has the characteristic of directly affecting people's subjective well-being (Diener et al., 1994). Therefore, user mood can act as a key variable to investigate how design promotes long-term user well-being (Desmet & Pohlmeyer, 2013).

Moods can provide information about the evaluations and judgments associated with behavior, which affect behavior. For example, affective feelings that can be felt when a goal pursued through the effort required to act is achieved provide information about the process and judgment of the action. In other words, the mood allows us to gain intuitive knowledge of the intensity and persistence of behavior If a certain type of requirement or knowledge of behavioral procedures and outcomes is activated by mood and activated knowledge matches mood, it will increase the intensity of mood influences on behavior. People often try to keep or change their moods. In these attempts, people use mood control strategies, which could be mental (e.g., thinking of pleasant memories) or behavioral (e.g., sports activities) (Morris & Reilly, 1987). Mood control strategies are integrated into our daily activities and habits, so we control our mood without being conscious of doing so (Parkinson et al., 1997).

The mood, which functions as a human-centered foundation, can be used in an ideal way to support current technology-driven and intuitive design approaches. For a potential technology to be used well from the user's perspective, the novelty of the technology must be accepted from the user's perspective. Moreover, interest in using autonomous vehicles in terms of users is directly related to the perceived time usefulness in vehicles. To better understand how users adopt innovative immersive technologies over the long term, it is essential to know how technology affects users' moods and how these moods affect user-technology interactions (Desmet et al., 2016). In this regard, it is important to understand that mood influences user’s behavior. this perceived time-driven 'user behavior' can be an important factor in establishing a potential future mobility SAV as a sustainable public transport service.

3

Exploring user activity and needs in SAV

· Experiment design

· Experiment stimuli

· Method

· Result

3. Exploring user activity and needs in SAV

This study focuses on finding design opportunities and factors that encourage or assist users in future activities on potential public transportation services, SAV. To understand the experience associated with users' activities in a shared self-driving car environment, I conducted experiments to determine what the users experience in the future SAVs and what their wishes and expectations are.

3.1. Experiment design

An experiment was designed with two main tasks in order to identify user needs, expectations, and design opportunities: One is to create a specific environment to observe the activity and experience of users in SAV, and the other is to allow users to evoke the use of future SAVs after a virtual experience and evaluate what they are likely to do, their expectations and wishes, and the desired mood through a self-report design method. Below is a briefly summarized figure of experiment design of the current study (Figure 9).

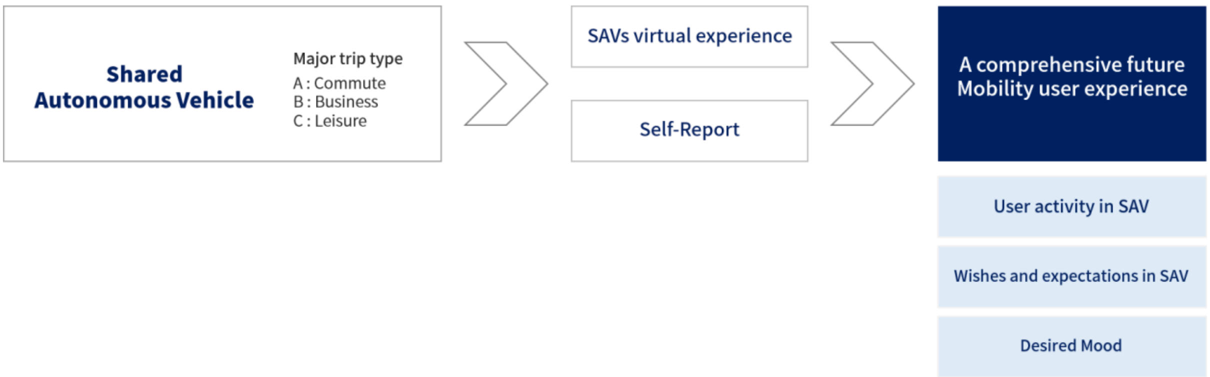


Figure 9. Outline of experiment

3.2. Experiment stimuli

3.2.1. Experience prototyping

Encouraging experimental participants to understand the concept of SAVs can be an essential factor in identifying user activities. In addition, experiencing a real SAV-like environment can create a sense of space and immersion for users. Therefore, I decided to create a space such as a future SAV and apply it to experiments.

To create a space like SAV, I referred to the literature and the SAV concept Amazon ZOOX, which was most recently released to the public. The literature stated that the most suitable SAV size for urban environments would be a four-seats vehicle with 3.0K. Indeed, the Amazon-owned ZOOX operating in urban environments is also designed to accommodate four people (Figure 10).

Figure 10. Amazon ZOOX, exterior and interior

The shuttle length is 142.9 inches (3.63 m), which is not suitable for the size of the indoor environment because it is the total length of the vehicle. Therefore, based on the fact that the ZOOX is located halfway between a Smart Fortwo and Toyota Corolla (Figure 11), I build an environment that considers the appropriate size between the indoor sizes of two vehicles. As shown in the figure, Toyota Corolla's interior size is approximately 106 inches (2.7 m), and Smart Fortwo's interior size is approximately 73.7 inches (1.87 m). The average value was calculated by comparing the sizes of the two vehicles, which resulted in 90.5 inches (2.3 m). Therefore, I decided to create a virtual environment with an indoor environment of 90.5 inches (2.3 meters).

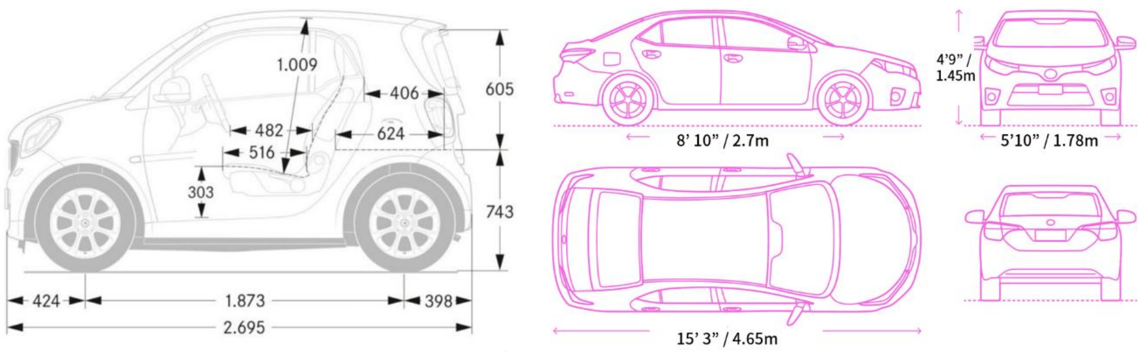


Figure 11. Smart Fortwo (Left), Toyota Corolla (Right) dimensions

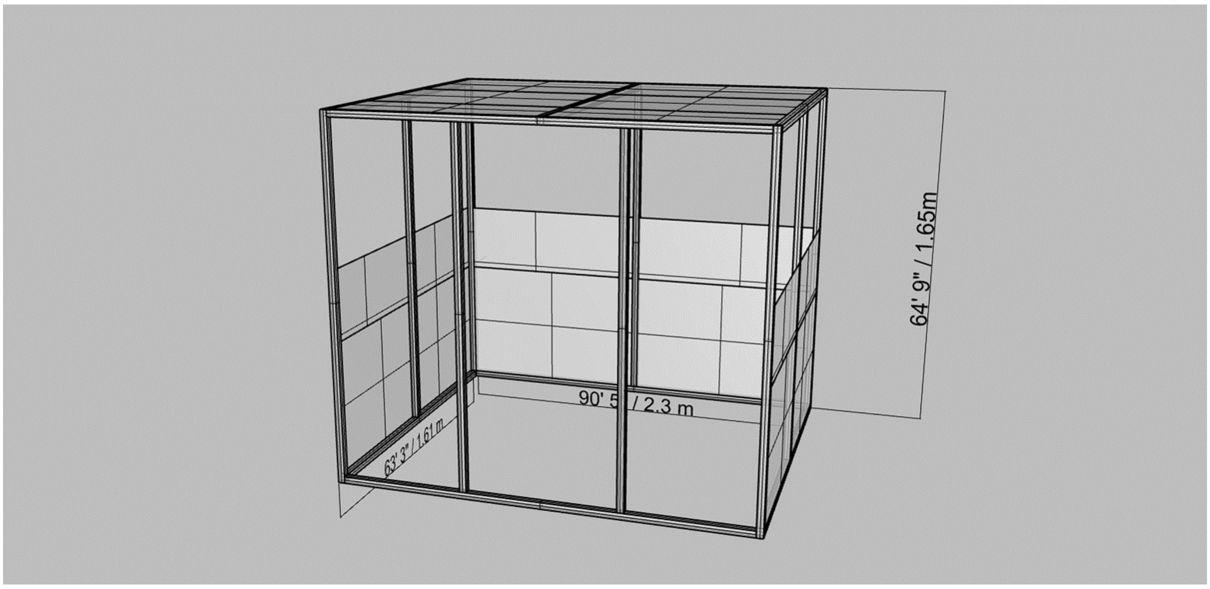


Figure 12. Virtual environment dimensions

Virtual space has been created to identify passengers' needs and activities for future public transportation services. "Experience Prototyping" is all kinds of representations designed to communicate, understand, or explore how the design relates to space, product, or system, and vivid experience can create subjective and lasting memories for participants, influencing designers' choices and decisions at every stage of the design and development process (Keane & Nisi, 2013). Thus, "informance" (for informative performance) and "bodystorming" (for physically situated brainstorming) resulting from a particular location could create "real settings through the actions of real people." Therefore, this method is a good design method for exploring design opportunities for future SAVs. This allows direct observation of the overall user experience of what future SAV passengers will do when sharing rides in the context of travel.

Figure 13. Virtual space for experiment

3.3. Method

3.3.1. Self-report measurement after virtual experience

This design method is used to identify users' activities and needs. In order to understand how users adopt innovative technologies, it is essential to understand how technology affects users' moods and how this mood affects user-technology interactions (Desmet et al., 2016). After all, the user's mood can be an important design factor when designing products and systems that meet and contribute to the user's needs.

To know what they feel and want through experiments to identify users' needs, it is crucial for participants to think about their thoughts or feelings in a specific shared space. The main advantage of self-report methods is that the participants could measure distinct mood types. Identifying and recording future users' "feel patterns" could be useful in areas of technology that aim to help people adopt new practices.

Conventional and reliable adjective-based approaches have been applied for quick and immediate self-report measurements. This method allows users to easily evoke their experiences and feelings by looking at the adjectives list and comparing their emotions with the list provided to find the appropriate adjectives. To apply the adjective labelling method to this study, I referred to the research literature that activates subtle mood measurements to label adjectives containing four mood states and eight distinct moods (Desmet et al., 2016). Additionally, I offered activity labelling sheet that the future SAVs passengers are likely to do on autonomous vehicles, referring to the literature that considers in-vehicle activity an important factor (Kwon, 2018; Wadud & Huda, 2019). The adjective-based labelling sheet consisted of 27 and the activity labelling sheet consisted of 21. Both labels had magnets attached to the back so that participants could easily move and attach them in the report sheet (Figure 14).

Figure 14. Activities and mood labeling with magnet

Applying these methods to this study allows us to obtain user-side needs and desires for the environment generated by the new technology and help them adopt the practices of the new technology.

Participants

A total of 20 participants were recruited to conduct the self-report study. Participants consist of 13 males and 7 females, and their ages ranged from 20 to 41 years old (mean = 26.9; SD = 4.3). 15 of the 20 included Master and Ph.D. candidates at the author's university(UNIST). The other five were recruited as outside participants to obtain objective data. Each group consisted of four participants and five groups. When forming a group, one outsider participant was included in each group. Before the main study, a pilot study was conducted to identify our missing point and supplement with 2 participants (Master and Ph.D. candidates)

Materials

The virtual environment experience was recorded using a camera to observe patterns and needs associated with the participants' activities. Additionally, to simulate the feeling of being in an actual vehicle for participants, I screened videos related to the surroundings that could be seen when traveling in a vehicle using a beam projector throughout the experiment (Figure 15).

Figure 15. Creating an environment from users sensitive and video recording

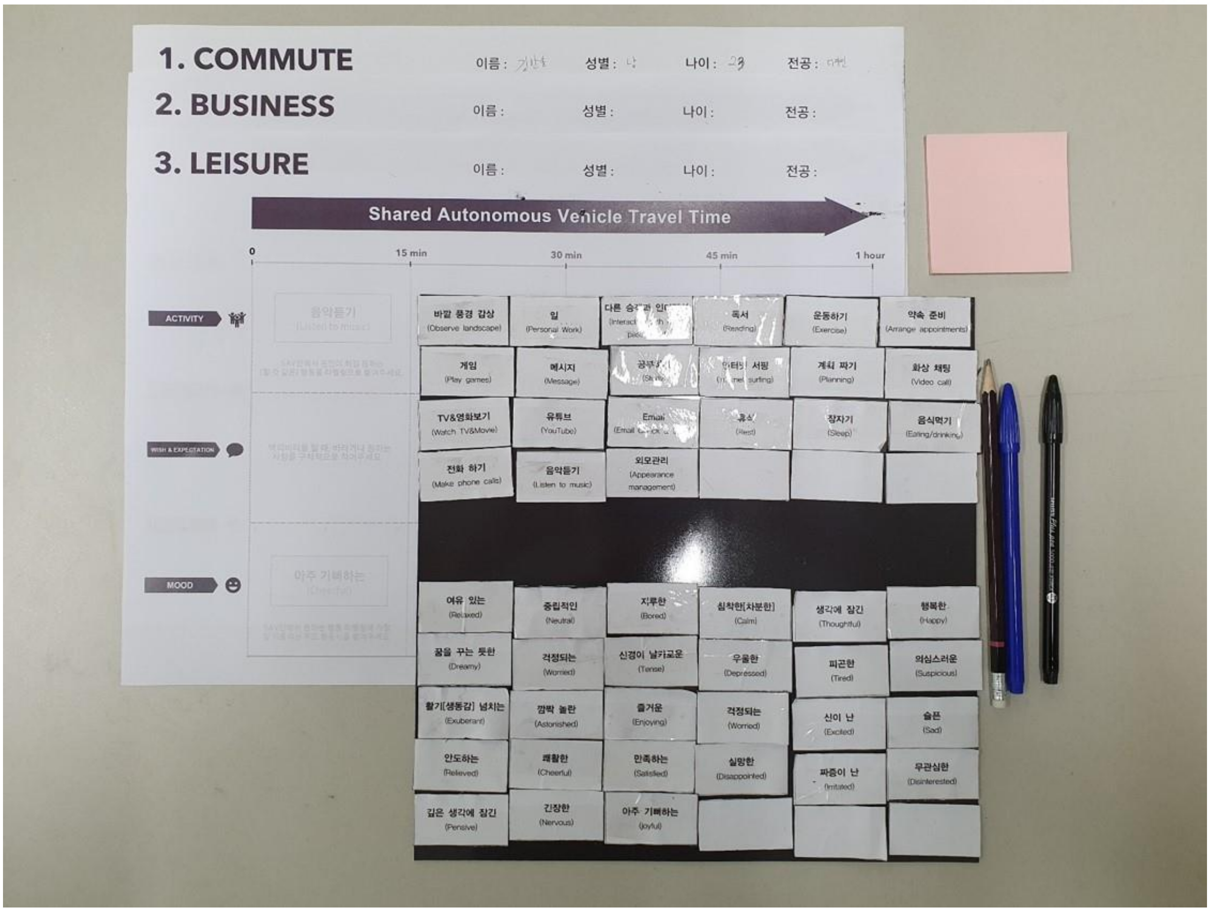


Figure 16. Material for experiment

For the self-report measurement, the self-report and labelling sheets were made, which were designed as follows. First, the self-report sheet was composed of three parts: (1) activity, (2) wishes and expectations, (3) desired mood. The activity part was to report in-vehicle activities that participants would likely do on an hour trip according to the three trip types (commute, business, leisure) based on their experiences in a virtual environment. The wishes and expectations part was to write down their needs specifically while doing in-vehicle activities. The desired mood part was to report their desired mood according to the activity. For the self-report making, A3 paper with three trip type was designed to help the participants express their wishes and emotional feelings in the space (Figure 16). Pencils and post-it were also provided for participants to express their thinking freely on paper.

Procedure

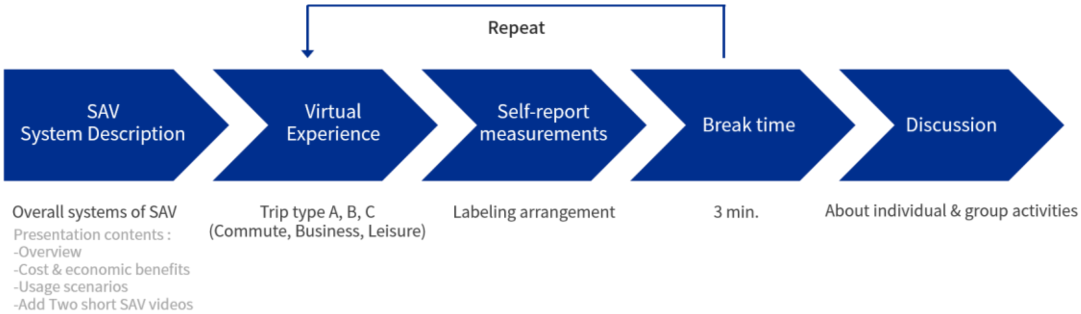


Figure 17. Procedure of experiment

To explore the experience associated with user activities by each of the three major trip types, At the study's first stage (Figure 17, SAV System Description), I made a presentation to help participants understand SAV and explained it to them for 10 minutes. This presentation mainly introduced the SAVs cost benefits, economic benefits, usage scenarios, and how to use SAVs, and played two short videos related to SAV for easy understanding. This session was conducted to give participants a general understanding of the SAV system and its operation. At the study's second stage (Figure 17, Virtual Experience), participants were given an assumed scenario that they boarded on SAV and traveled one hour for each of three scenarios: Commute, Business, and Leisure. I used Autonomous Mobility on-Demand service (AMoD) as a way to board a group into an SAV in a virtual space. This is how the nearest passenger among the four people who ordered SAVs using a mobile application gets on first. Then, the remaining people by distance get on in order, so we asked to board participants on virtual space in this way. In addition, participants were asked for a scenario in which they didn't know each other and experienced one hour of future travel for 10minutes. This procedure was repeated three times for each trip type (Commute, Business, Leisure). At the study's three stage (Figure 17, Self-report measurements), participants were asked to find a label suitable for their thoughts and feelings through the labeling paper provided and attach it to the form. The contents of the sheet are designed to put in an hour trip type in the future SAV with activities, desired mood, wishes, and expectations that participants would likely to do by time. After that, 3 min break time was given (Figure 17, Break time). Then, participants were asked to think about the contents of group activities in which 2 to 4 people share SAV and individual experiences. The discussion was recorded for each group.

3.4. Results

This study examined the future passenger's activities, desired mood, and needs within the SAV through observations and self-report measurements by building an environment similar to SAVs. If SAV is operated as a public transportation system, it can be used for various purposes such as commuting, travel, and business trips like conventional public transportation. Consequently, depending on the three main types of trips, the user's in-vehicle activities and the desired atmosphere would be different. Therefore, the results of this experiment show the following figure related to user activities for each of the three important trip types: commuting, business trip, and travel during SAV operation. The results of the experiment are as follows.

3.4.1. Future passengers' experience with SAV in commuting situations

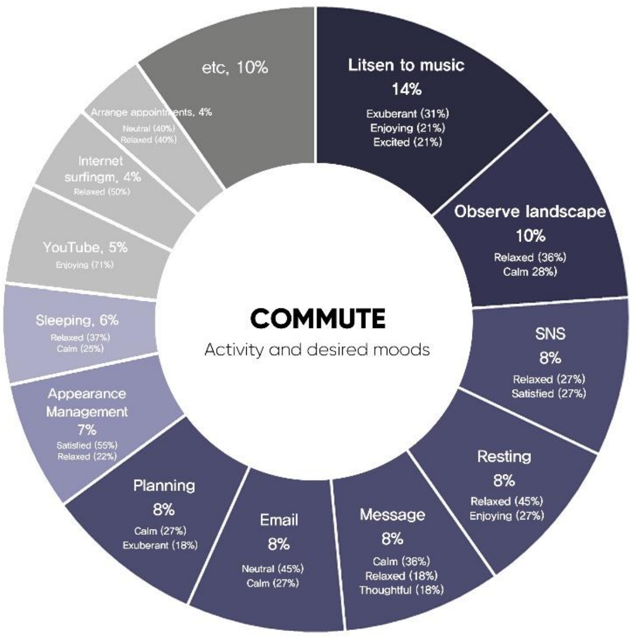


Figure 18. Participants' future activities and desired mood in the 1-hour commute trip type situation.

This study identified the most activities, desired mood, and wishes in SAV through two design methods. Figure 18 illustrate the frequency percentile of participant's activities and liked mood on an hour commute. 'Listen to music' was the most frequently mentioned (14%). participants wanted to start the day exuberant listening to music if they used SAV early in the morning to get to work. It was followed by SNS, Resting, Message, Email, Planning (8%), Appearance management (7%), Sleeping (6%), YouTube (5%), Internet surfing (4%), Arrange appointment (4%), etc (10%). During the one-hour commute trip, the mood participants wanted to feel was 'Relaxed' (n=8), followed by 'Calm' (n=5), ‘Enjoying’ (n=3), ‘Exuberant’ (n=2), ‘Neutral’ (n=2), ‘Satisfied’ (n=2), ‘Excited’ (n=1), ‘Thoughtful’ (n=1), In the discussion session, most participants agreed that they were unlikely to travel the SAV as a group (two or more people) for commuting. Participants said they would personally commute considering that if they traveled with their colleagues during busy commuting hours, they might be late for work place, and that vehicle would be allocated according to the distance when ordering SAVs through mobile apps.

3.4.2. Future passengers’ experience with SAV in business situations

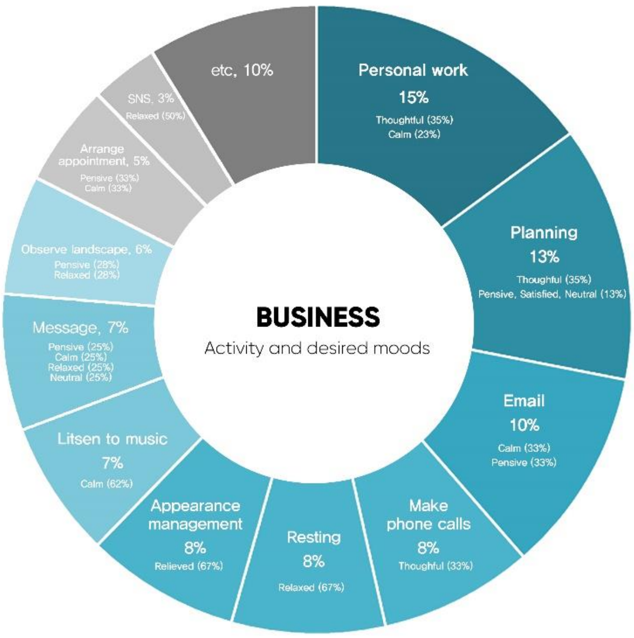


Figure 19. Participants' future activities and desired mood in the 1-hour Business trip type situation.

Figure 19 illustrate the frequency percentile of participant’s activities and desired mood on an hour business situation. ‘personal work’ was the most frequently mentioned (15%). Participants wanted to do Personal work (15%) to finish their work in a business trip that was an extension of their work. Furthermore, the top activity charts on the graph show that they wanted to perform task-related activities in SAVs by Planning (13%), Email (10%), and Make phone calls (8%), It was followed by Resting, Appearance management (8%), Listen to music, Message (7%), Observe landscape (6%), Arrange appointment (5%), SNS (3%), etc (10%). During the 1-hour business trip, the mood participants wanted to feel was ‘Calm’ (n=5), ‘Pensive’ and ‘Relaxed’ (n=4)’, followed by ‘Thoughtful’ (n=3), Neutral, Relieved (n=2), etc (n=1). During the discussion, most participants said they wanted to do work and meeting activities in SAV vehicles and wanted technologies such as multi-device linkage. In the case of group activities, they said hoped there would be a large screen to share. They wanted a calm and serious in the mood and chose ‘Calm’ as the most appropriate adjective expression.

3.4.3. Future passengers’ experience with SAV in leisure situations

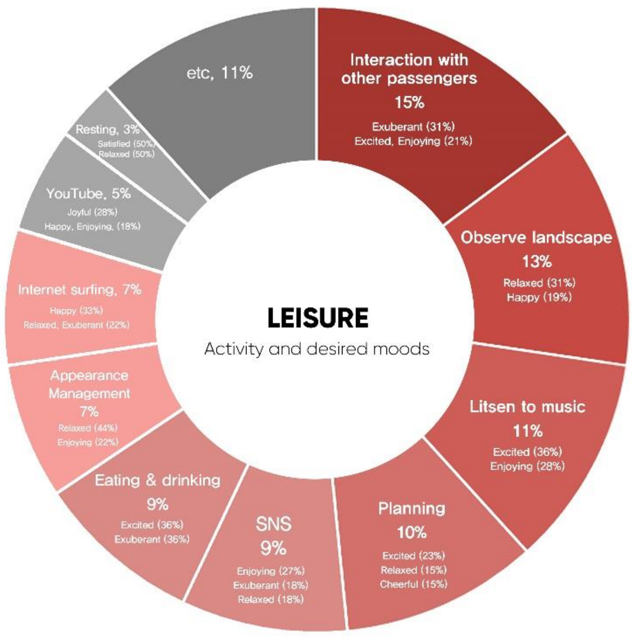


Figure 20. Participants' future activities and desired mood in the 1-hour leisure trip type situation.

Figure 20 illustrate the frequency percentile of participant’s activities and desired mood on an hour leisure situation. ‘Interaction with other passengers’ was the most frequently mentioned (15%). Participants wanted to communicate with others through the excitement of going on a trip. In addition, the participants wanted to feel 'Exuberant' while communicating with others in the SAV. The top activity charts on the graph show that they wanted to do some of the common activities that we do when we go on a trip by conventional vehicles at SAV and ‘Observe landscape’ (13%), ‘Listen to music’ (11%). It was followed by ‘Planning’ (10%), ‘SNS’, ‘Eating & drinking’ (9%), ‘Appearance management’, ‘Internet surfing’ (7%), ‘YouTube’ (5%), ‘Resting’ (3%), etc (11%). During the 1-hour leisure trip, the mood participants wanted to feel was ‘Relaxed’ (n=6), ‘Enjoying’ (n=6), ‘Excited’ and Exuberant (n=4)’, followed by ‘Happy’ (n=3), ‘Cheerful’, ‘Joyful’, ‘Satisfied’(n=1). Users were expecting to do activities such as eating food that they could not do in public transportation. The biggest reason for this was the expectation that technology would allow us to do what we couldn't do in our daily lives. In the discussion session, most participants said they wanted to enjoy their trips and do entertainment activities during travel time. So if they go on a trip as a group, they said they want to play loud music and drink and eat food. They wanted excited and enjoying in the mood and chose ‘Excited’ as the most appropriate adjective expression.

3.4.4. Data integration

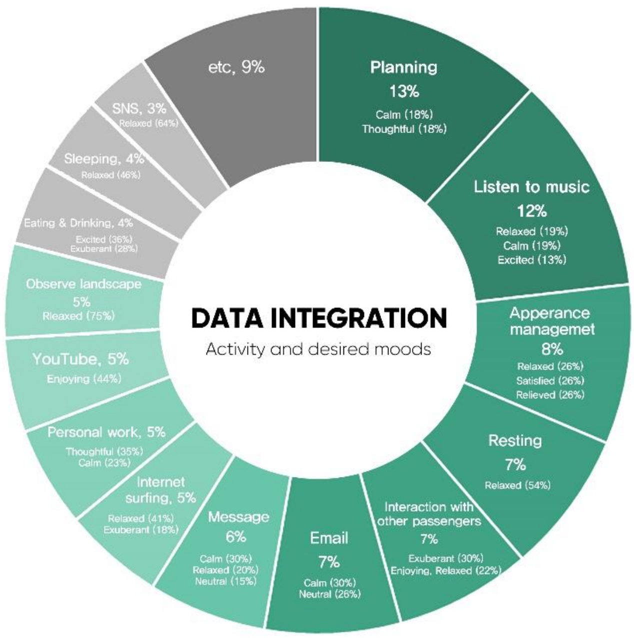


Figure 21. Participants' future activities and desired mood in the 1-hour three major trip type integration.

Based on user activity and emotional feeling, Figure 21 presents an important priorities and components when considering user-side design opportunities within SAV based on user activity and emotional feeling. First, concerning the passenger’s perspective, ‘Planning’ (Top1, 13%) activity is most important priority. Passengers considered it important to make plans even in the vehicle. In other words, for them, transportation is a means used to achieve individual purposes, and it is a space where they have thoughts and plans on what activities to do and what tasks to do when they arrive at their destination. They seem to think a lot about spending their time productively and efficiently during travel time in their own way.

In the case of 'Listen to music' (Top2, 12%), participants liked to do other things while listening to music. Namely, listen music were often used for multi-tasking by participants. Next, ‘Appearance management’ (Top3, 8%) was an activity that passengers wanted to do before getting off. Next, ‘Resting’, ‘Interaction with other passengers’, Email (Top4 7%). In ‘Interaction with other passenger’ they wanted to interact with other passengers in a system and space that was changed by new technology, which was not seen in traditional public transportation. It was followed by ‘Message’ (Top5 6%), ‘Internet surfing’ (5%), ‘Personal work’ (5%), ‘YouTube’ (5%), ‘Observe landscape’ (5%), ‘Eating & drinking’ (4%), ‘Sleeping’ (4%), ‘SNS’ (3%), etc (9%).

3.4.5. Strategies to explore design opportunities in SAV

This study aims to identify design opportunities to provide the best experience for user activities within SAVs. Therefore, I first analyzed the activities users want to do in future SAVs and the desired mood accordingly. With this data, it can focus on designing opportunities based on user needs within the SAV. Therefore, I consider the top five user activities in the integrated chart graph as important design opportunities and focus on them. We need to focus on are as follows (Figure 22).

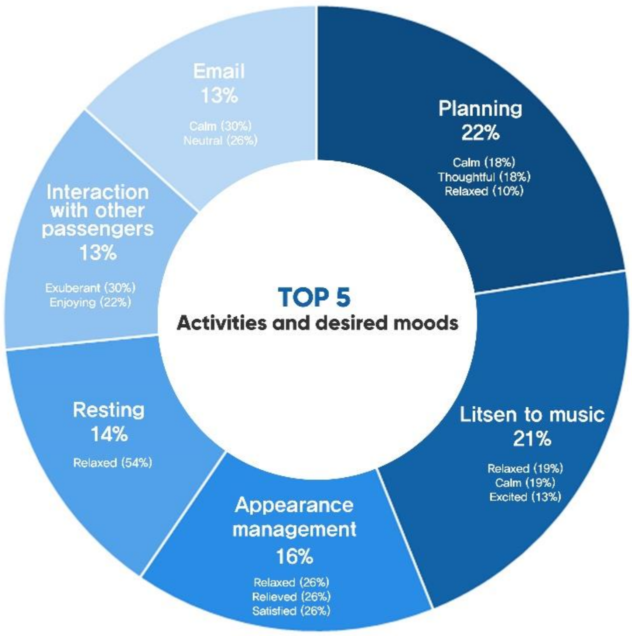


Figure 22. Five priority activities

Figure 22 represents the frequency percentile of activities and the desired mood by organizing the integrated data once again. The top five activities are used as priorities to identify new design opportunities. I consider 'interaction with other passengers' and 'Email' ranking together because they are tied at 13%. In addition, I also provide data that analyzes and groups participants' wishes and expectations for each activity (Table 1). The user's wishes and expectations in Table 1 are organized by grouping their needs of all trip types.

Table 2. Wishes and expectations based on user activity priorities

Activity	Ranking	User's Wishes and expectations	Desired mood
Planning	1	-Wifi router, Secondary internet Devices -Space and storage for bags -Use personal lighting to create mood -Partitions that create personal space -Shared display showing socioeconomic issues -Screen to plan and check daily schedule -A screen that provides a large screen in conjunction with a mobile phone -Provide information about the time remaining and current location	Calm Thoughtful
Listen to music	2	-Wifi router -Wireless charger -Personal radio or headset -Function to hear a song from a private seat -Bluetooth features and music sharing -Ensuring a quiet environment	Relaxed Calm
Appearance management	3	-Screen as a mirror function -Need to check appearance right before work -Want to be protected from the surrounding eye -Space and desk for use with cosmetics	Relaxed Relieved Satisfied
Resting	4	"I don't want to be disturbed when I'm resting" -Brightness adjustable personal lighting -Function to hear good songs randomly -Indirect light of appropriate temperature. -Provide information about the time remaining and current location	Relaxed

Interaction with other passengers	5	-A display of news and issues for free communication -Want to receive information about peers and contact them by message -Baggage storage for travel -Table to share food -A display that shares information or content -Pleasant environment -Customizable lighting	Exuberant
Email	5	"Desk where I can put my laptop on" -Personal lighting -Function to provide notifications at a set time -Personal space independent of the surroundings -Wifi router and charging terminals -Wireless charging function	Calm

Through Table 1, A careful look at users' needs according to high-priority activities allows them to explore design opportunities within the SAV. For example, those seeking design opportunities within an SAV may think of design in consideration of priority needs through the table proposed. It is important to apply design elements based on user wishes and expectations to various scenarios and go through the idea process in this process. In other words, the process of specifying design ideas that take into account important activities, needs, and mood, is needed. I did not specify the content separately when users' needs were duplicated for each activity. Therefore, this data can be used effectively when considering new designs in SAV.

4
Identify design opportunities for SAV users

- Method
- Result

4. Identify design opportunities for SAV users

4.1. Method

4.1.1. Pilot test

Pilot tests were conducted using data derived before the designer workshop. In this process, I wanted to find out how designers with expertise in automobiles think about the data suggested and what they focus on which part in SAV. The materials provided in this course are as follows: (1) A card for visually conveying user priority activities, requirements, and desired mood (2) A total of one hour of data divided by three trip-type trips in 15 minutes (3) Paper for visualizing by designers (4) Presentation to describe SAVs. (5) Provides a SAV concept image board that evokes designers of inspiration.

Figure 23. Pilot test

Participants with more than three years of practical experience in the field were selected to recruit professional participants. The average age was 36.7 years, all of whom were male. The workshop was held in the seminar room where they worked.

Table 3. Pilot test participants

Designer	Age/gender	Occupation	Career	Work experience
A	43/Male	Car exterior designer	17 year	Ssangyong motor
B	36/Male	Car exterior designer	9 year	Ssangyong motor
C	35/Male	Advanced researcher	7 year	Ssangyong motor
D	33/Male	Car exterior designer	4 year	Ssangyong motor

Result

Designers with expertise in automobiles raised questions about the current SAV structure and said that they should avoid boarding on both sides if technology is possible. The most important activity they thought was rest. They talked about their thoughts on SAV at the ideation stage, recalling their personal public transport experiences. The biggest issue was privacy issues, and they all expressed that addressing privacy issues is an essential consideration for SAV to succeed as a continuous mobility. In addition, one said that consideration for seats and interactions is needed if a person or passenger is on board. The designer of the research base said that creating a profit structure through advertising and promotion would make it cheaper. Other designers also mentioned sanitary aspects of shared spaces. As a result, privacy issues in shared spaces have been the biggest issue. the results of the pilot test are provided in the table below (Table 4).

Table 4. Pilot test results

Designer	Selected Priority Activity	Ideation
A	Resting	- I think that SAV will follow the basic form of public transport that we use today. - It seems difficult to sleep comfortably in the current space. - The advantage of public transportation is that it can accurately predict arrival and departure times. - I don't want to sit face to face with strangers.

		- Personally, I'm not interested in seeing the scenery outside the window. Screen information is preferred instead of windows.
B	Resting, Planning	- Currently, SAV has potential, but the threshold seems clear. - Personal privacy is an important factor. Therefore, I thought of an X-shaped structure. - A partition or space separation of the sheet is required. - Ride sharing can be a very unpleasant experience. - Luxury concept is too much to be public transportation. I think economy seats on the plane are appropriate. - I thought of a screen-like profit structure on a wide-area bus.
C	Interaction with other passengers	-It seems relevant to the current issue of hygiene. -It is necessary to board in front and back of the vehicle or consider various structures. -SAV space may become a community. Services that assist this should also be considered. -The space open to each other is uncomfortable. At least a partition is needed.
D	Resting	-Seat locations and partitions seem to be needed to create personal space. -Consider riding alone and two or more people. -Focus on privacy and think about how to ride a SAV, such as the shape of a car that opens front and back doors.

Complementary points

Through this pilot test, I was able to find some complementary points. Firstly, in the case of cards, there was more data than necessary, so designers were confused about which part to focus on. Furthermore, the image-board provided for inspiration of designers needed to be modified because there were too many images related to group activities rather than individual activities. Lastly, one-hour travel data was suggested that printing on large paper (A1 or A2) was better for visibility. The proposed sketch will be added to the Appendix chapter through pilot testing.

4.1.2. Designer workshop

The final goal of this work is to identify and propose design opportunities that can provide the best experience for future mobility users. The designer workshop aims to create and visualize ideas that satisfy the wishes and expectations related to user activities. Therefore, five professional designers were recruited to identify what design opportunities were within the SAV to meet user needs. In addition, we explored and discussed specific design opportunities and solutions that can be provided to users through designer workshops.

Participants

Five design-related practitioners, such as product designers, UX designers, App/web developer, and a UX planner, were recruited to participate in the workshop. The criteria for recruitment were those who graduated with a bachelor's degree in the Department of Design and worked for three years or more in this field. The participants' age ranged from 26 to 32 years old, and the average was 30 years old. Table 2 shows the information about each designer.

Table 5. Designer workshop participants

Designer	Age/gender	Occupation	Career	Work experience
A	32/Male	UX planner	3 year	Hyundai Motor
B	31/Female	Product designer	8 year	Cuckoo
C	31/Female	UX designer, planner	4 year	NC Software
D	30/Male	Product Designer	3 year	HEI
E	26/Female	App/Web Developer	3 year	SUMMIT Design

Material

The materials used in the designer workshop were PowerPoint, SAV’s interior model, card with user needs, evaluation handouts. The PowerPoint included an introduction to the study, An description of the SAV, and the goals of the workshop. SAV's internal model (Figure 24) was 3D printed with the interior of Amazon ZOOX's SAV concept model. It is designed to show designers a sense of space in a shared four-seats vehicle. In the case of cards, the front page included the appropriate image and desired mood for the five priority of in-vehicle activities of the user. The back page of the card consists of the wishes and expectations that users want for each activity (three major trip types).

Figure 24. Card(Left), SAV's interior modeling(Right)

The handout was provided with a personal evaluation sheet to evaluate each designers' ideas. Additionally, they were provided image board regarding the SAV concept and product images. Through this process, design opportunities to support and encourage user activities within the SAV were expressed as visualized ideas.

Procedure

Because of COVID-19, the five designers were divided into two groups. For the workshop, two computers were connected to each screen in each room, and presentation materials and screens were shared through ZOOM. The workshop lasted a total of two hours. The order of the designer workshop progressed as follows. First, background knowledge, research goals, designer workshop purposes for this study were described. Second, the card and idea evaluation sheet with five priority activities selected by users were explained. Third, designers spent 10 minutes looking at cards, 3D printing models, and additional data, and then 30 minutes sketching their ideas. Fourth, after the sketch, the designers shared their ideas one by one. At this time, Except for designers who share ideas, other designers rated the evaluation on a five scale. Lastly, designers were given the discussion stage to enhance promising ideas.

Table 6. Designer workshop timeline

Stage	Contents	Duration
1	Understanding SAV with presentation	30 min
2	Card and handout description	10 min
3	Ideation and sketch	45 min
4	Evaluation	10 min
5	Discussion	20 min
6	Workshop close	5 min

Figure 25. Designer workshop

4.2. Results

Through the designer workshop, ten design ideas and six idea sketches were generated. the design opportunity for users was proposed to meet user activities and their wishes. Table 4 includes an explanation of what elements designers focused most on and what ideas they suggested to encourage user activity.

Table 7. Design opportunities for SAV

Idea	**Focused elements**	**Examples**
(1). Display	- Personalization for privacy - Modularity - Connectivity - Expandability	‘I think one product that can perform many roles should be applied to SAV’ (30, male, product designer) -It is installed on the roof of the SAV and can be used by pop-up when passengers want to use it and hide it on the ceiling if they don't want to use it. -The display can mirror personal mobile phone or laptop. -The role of this is not just a display, it blocks passengers view, creating a personal space and providing space with mood lights’.
(2). Modular partition	- Private space - Modularity	‘I think passengers would prefer personal rest to interaction with others.’ (30, male, product designer) -Separate the space by installing a large partition (horizontal and vertical) in the center of the SAV. However, passengers can hide the partition up and down in consideration of riding with colleagues, friends or someone.
(3).Information-focused products	- Comfortable resting and good experience	‘Wherever I go, I always check my current location and time.’ (26, female, App/Web Developer) For a comfortable rest in SAV, the display-mounted handle product provides a service that informs the current location of the vehicle and the time remaining to the destination and sets the alarm. In addition, The device informs passengers of their seats with LEDs and simple greetings when they board.

(4). Cube Structure	- Comfortable resting - Privacy and hygiene issues	‘I believe that with modern issues, hygiene and privacy are important factors in a shared space.’ (32, male, UX planner) It provides independent space for a four-seater SAV in cube form. Each independent space is equipped with a sunroof and an air conditioning system, which allows for consideration of ventilation and hygiene. The intermediate partition blocking the space is open and closed, so two passengers can share the space if they want.
(5). Modular Private space	- Personalization and modularity	‘Sharing a shared space with strangers is a great stress.’ (31, female, product designer) Similar to idea (2), it uses a folding partition and, like a mist glass, the partition turns foggy if the passenger wants it.
(6). Compatible services with users personal devices	- Connectivity	‘Smooth compatibility with SAV devices and gadgets would lead to better cognition and experience for users.’ (31, female, UX designer and planner) It is a service that is compatible with individual users' devices and automatically turns on songs and news that passengers used to play when boarding.
(7). Customized services based on user routines	- Personalization	‘If we provide personalized experiences when boarding based on user data, passengers would feel ownership of SAV.’ (31, female, UX designer and planner) Convenience facilities in the SAV such as lighting, seat angles, and air conditioners can be set as desired, making it easy to reproduce one's own environment whenever one rides the SAV. It provides a reservation service in repetitive daily life such as commuting and provides a setting environment desired by each passenger when boarding.

4.2.1. Idea

Six out of ten ideas were visualized. Three of the six sketches were ideas for the product (1~3), two for SAVs structure to be restructured (4~5), and one for services using mobile apps (6). The card that all five designers considered as a design opportunity for SAV passengers was 'Resting'. The specific moods that passengers wanted on the resting cards was ‘relaxed’. All the designers chose 'Resting' cards, but they consider all the data and cards to make valuable ideas.

4.2.2. Focused elements

At the designer workshop, which was based on user activities and wishes, designers thought that users' priority activities could be extended from ‘Resting’. Therefore, they focused on factors to provide users with a comfortable rest. Especially, keywords such as personalization and modularity have been mentioned, with designers focusing on the environment in which SAV guarantees individual privacy and the function of modules to expand to group activities of more than two people if necessary.

4.2.3. Conclusion

As a workshop idea, three design opportunities were proposed: product, structure, and service. For products, displays have been proposed to provide personal space and solve privacy problems, and secondly, the idea of continuously providing information (remaining time, current location, etc.) of the SAV system to allow users to rest during travel time.

For SAV structures, the idea of turning a four-seater vehicle into a cube-style single room to put in an air conditioning system and care for privacy and hygiene is proposed as the first way to provide users with personal space. The second and third ideas were also presented to create a private area by using large modular partitions to blur, fold, or hide partitions when users want to.

In the case of the service, a service idea was proposed in which the convenience facilities in the user's seat were connected to the personal device and were smoothly compatible when the user boarded the SAV. For example, if a user who was waiting for a SAV while watching Netflix gets on board the SAV and sits in his seat, Netflix, which used to be watched on speakers and TV, turns on. Secondly, it is a service idea that sets reservation, lighting, seat angle, air conditioning system, etc. as a mobile app according to user data and routines. These services allow users to form a sense of ownership, such as a private vehicle, and to pre-set their rooms or spaces to customized settings before boarding when using the SAV again.

5

Discussion

- Interaction opportunity enhancement
- Timely travel care
- Internal locus of control
- Borderless isolation
- Examples

5. Discussion

This section presents a discussion of design opportunities that can be applied to future SAV designs through results that come from considering users' activities, desired mood, wishes and expectations for future mobility SAVs. In addition, I suggest an example of applying these design opportunities to each of the three main trip types. In the case of the example, I used the overall experimental data to apply the user needs to be considered in future SAV designs. Therefore, this can be used as a reference for future SAV designs.

5.1. Interaction opportunity enhancement

In this study, I identified that user activities and needs vary depending on the three trip types. Considering the impact of SAV travel types on user activity, users preferred to engage in personal activities (work, rest) for work-purpose trip types, such as commuting and business trip type, and identified task-supporting design needs. However, in the leisure trip type, participants preferred interaction and communication activities with other passengers and expressed design needs for shared activities. This means that participants have different needs depending on the objectives and situations they wish to achieve on their travel. namely, user activities may also be different. Therefore, SAVs need to develop designs to enhance their experiences in situations. Specifically, the structure, products, and services of SAV, which provide flexibility in personal and group activities of two or more people according to user needs, should be designed to be easily transformed to suit each situation.

5.2. Timely travel care

Providing participants with information related to the SAVs operation was identified as an important thing. Related literature suggests two types of presence during travel: 'transition' time prepares travelers for their destination, while 'time out' time allows travelers to relax from obligation (Jain & Lyons, 2008). In this study, participants' demands were also identified to prepare for "transition" and to efficiently use "time-out" time. They wanted to value their time during the trip and expressed a need to visually receive information and functions such as SAV's current location, time remaining, and notification settings. In fact, increasing the information level for AVs can reduce the anxiety of potential users, and increase their reliability (Du et al., 2019). In this regard, It should be noted that it is effective to provide this information personally because different passengers may have different destinations, and the need for visual information in real time should be considered. In addition, in order to encourage individuals to engage in various activities, features such as setting alarms are additionally provided, and such services or systems should be located near the user and conspicuous. Information provision is an important factor in increasing trust in vehicles and can have a positive influence as an alternative to direct experience (Paddeu et al., 2020).

5.3. Internal locus of control

"Internal locus of control" is a social psychology concept that corresponds to the belief that events originate from one's actions and that individuals can control one's life. I identified through experiments that participants wanted to directly control several features of indoor environmental control, such as seat angles, lighting, and air conditioning systems in SAV vehicles. These demands are not reflected in existing public transportation, but SAVs can also provide control to users. because It carries relatively fewer passengers than buses and taxis and have higher utilization of space. In addition, customized services can be provided through the utilization of space. Specifically, SAV uses mobile APP for vehicle reservations and orders, so personalized services such as lighting, seat angles, and air conditioning system settings on private seats can be considered during the initial App service design step. In addition, user data can be collected to play music and movies based on preferences and store settings to reflect these environments on the next booking. These customized services allow passengers to feel that the vehicle is concentrated on them and form psychological ownership of the vehicle. Psychological ownership can facilitate the use of autonomous vehicles (J. Lee et al., 2019).

5.4. Borderless isolation

The key factor to the SAV scenario is that vehicle space is shared. In other words, users must accept ride sharing with others they are not familiar with, which is closely related to the user's individual comfort and privacy. According to literature, there is an invisible boundary surrounding a person's body to distinguish between personal spaces and not disturb others (Sommer, 1969). Especially in SAVs, passengers spending time together in shared spaces can cause great inconvenience for individual activities and relaxing. Comfort can affect the continuous acceptance and adoption of SAVs (Paddeu et al., 2020). In this study, participants were also able to identify user needs that wanted to be guaranteed privacy and personal space when they wanted to rest and do certain activities. Therefore, to encourage comfortable user activities in SAVs and address privacy issues, design development should be made to provide personal space as needed. In the designer workshop, a way of placing a modular partition in each seat and separating the SAV structure into four rooms was created to solve the problem. An important point in this part is to enable selective activities (individuals, groups) and increase the usefulness and recognition of SAVs by providing control over spatial separation individually to users.

5.5. Examples

I recruited seven participants who participated in the first experiment to apply four design opportunities to the three main trip types. After that, participants were asked to place the most preferred design opportunities for each trip type. I tried to include all of their desired experiences in this sketch as the author of this study through user-centered experiment results and designer workshop data. The explanation for the example is as below. Each example contained images and descriptions in the table.

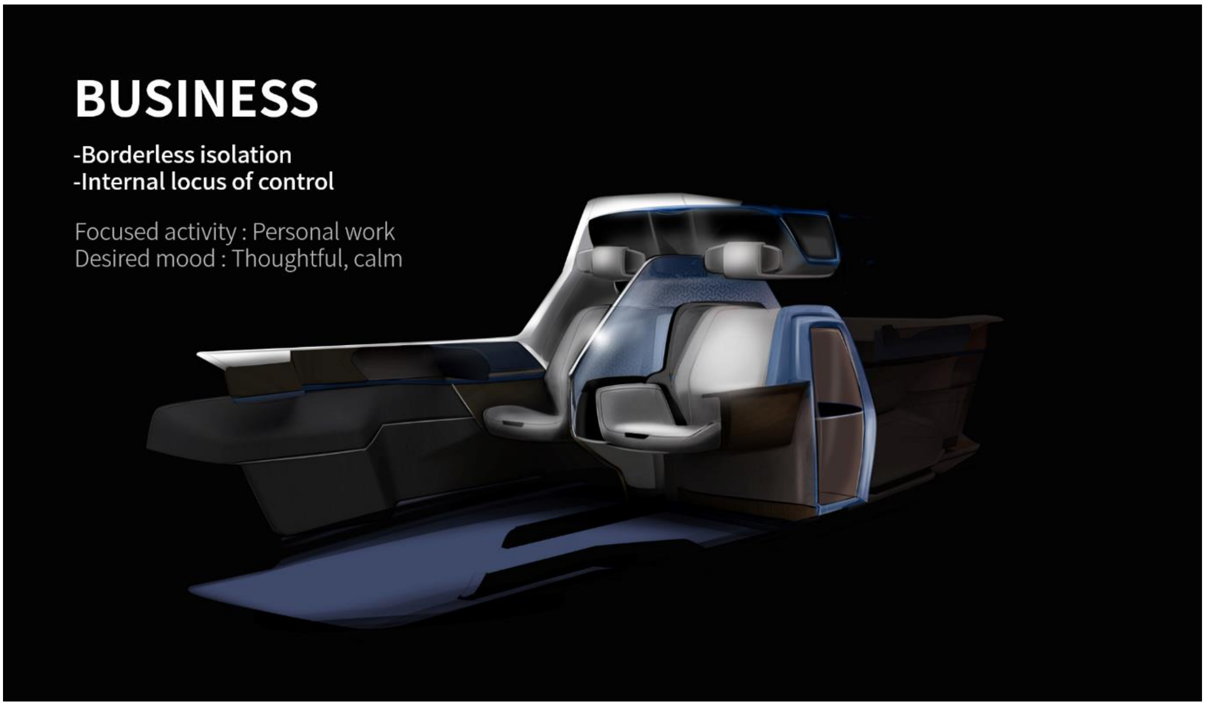
5.5.1. *Commute*

Figure 26. Visual examples of commute trip types

Figure 26 shows an example image that takes into account user needs within the SAV. In the case of commute, participants responded that three design opportunities were important. First, Borderless isolation, second, Internal locus of control, Third, Timely travel care. In addition, this example considered the results of the user's activity experiment. Therefore, this example focuses on supporting and encouraging resting.

As shown in the figure, this example provides four separate rooms for each passenger. In this study, participants did not want to interact or engage in group activities with others for commuting. They strongly preferred SAVs to be optimized for themselves and to be able to relax during their commute. The description of the function is as below. Each room is made in a modular format. In addition, I also added ideas considering the hygiene of shared spaces. Control features include mood lighting dials, UV sterilization, and sunroof function. The seats are angled enough to lie down and information such as entertainment and news is provided through the screen. Windows can be blurred when users want, such as mist glass. The display right in front of the seat provides entertainment elements such as news and YouTube. The user also controls the color and brightness of the interior lighting freely.

5.5.2. *Business*



There are two design opportunities applied to business trip types according to user priorities. First, Borderless isolation Second, Internal locus of control. For business trips, users preferred group activities but wanted to switch to their own space if necessary. Also, they wanted to keep their luggage and work related to work. Personal work is the number one activity in business experiments, And the mood that users wanted was calm.

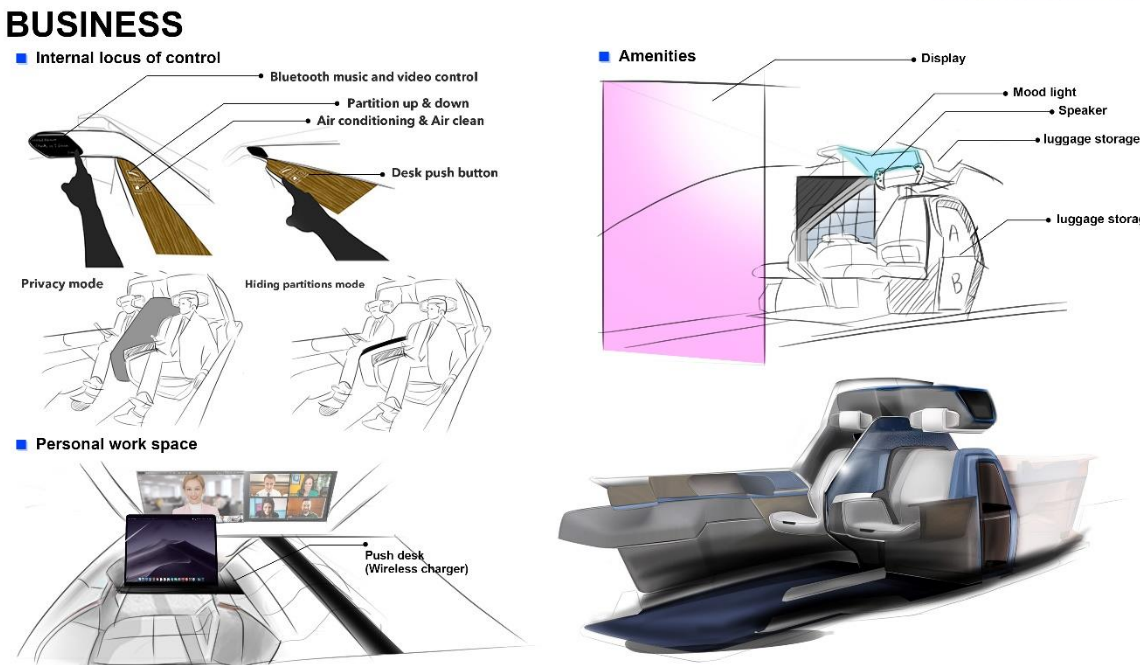


Figure 27. Visual examples of business trip types

This concept is a four-seater vehicle, and there is one more space that mirrors the picture shown. I apply work-related convenience functions to the locus of control. Thus, Bluetooth and video control functions are applied to support work-related activities. Hidden desks are provided with a simple touch and can be partitioned to separate spaces according to various situations. The front has a screen function that mirrors personal devices, providing multi-tasking.

5.5.3. Leisure

There are two design opportunities applied to leisure trip types according to user preference. First, interaction opportunity enhancement. Second, Timely travel care. In addition, focused activity is interaction with other passengers, and the desired mood is exuberant.

Interaction opportunity enhancement

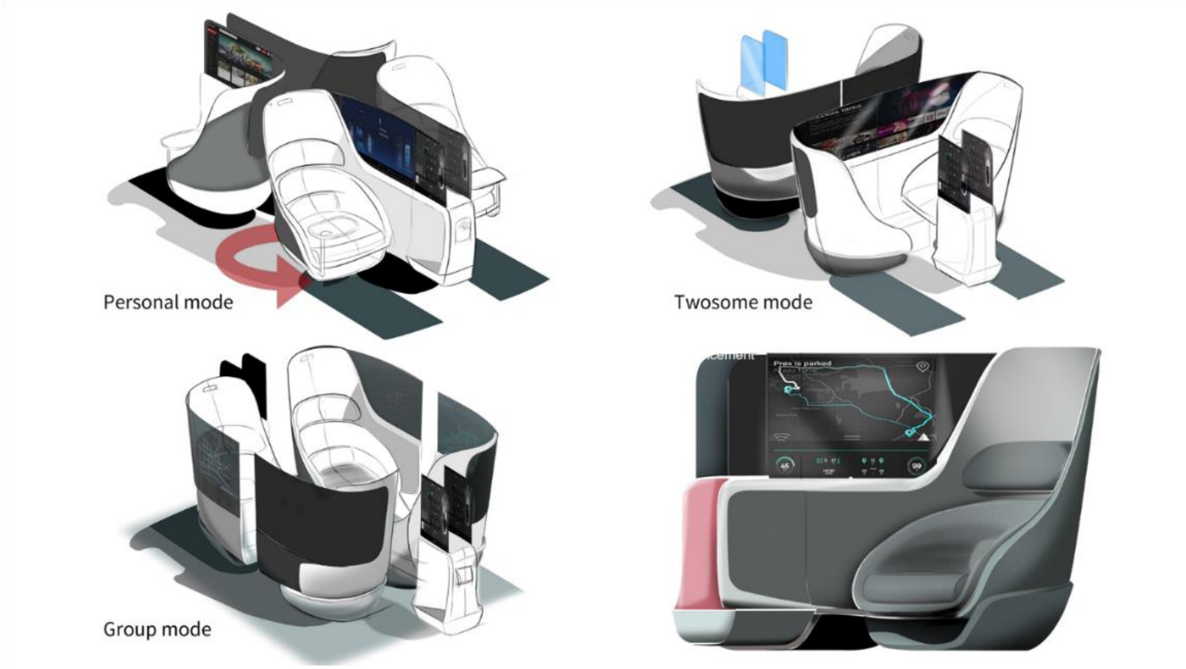


Figure 28. Visual examples of leisure trip types

In the case of a travel trip, it may be divided into individuals or two or three or more persons. Flexible transformation should be proposed according to needs and situations to encourage their comfortable travel. Therefore, this model provides a total of three modes. The three modes can be modularized from the user in the private seat. Also, screens in private seats can be used as partitions to create private spaces. Thus, users can choose their own mode and receive flexible interactions through this design. The touchscreen provided next to the private seat provides information on the SAV system and can freely use the internet if necessary.

6

Conclusion

· Design implications

· Limitations and future study

· Expected contributions

6. Conclusions

Until recently, research on SAVs seems to have spotlighted only the overall system operation factors rather than user-side acceptance of technology. However, Throughout the history of past innovations, we already know that it is insufficient to consider technologies and users separately. In order for a novel technology to be adopted and usefully used by users, user-centered research is essential. Therefore, this study tried to identify design opportunities that provide and enhance positive user experiences for SAVs that bring many socio-economic benefits. Specifically, I regarded in-vehicle user activity as an important factor due to vehicle automation and attempted to understand user needs according to trip type. To achieve this, I conducted the literature review to explore the SAVs overview, in-vehicle activity, and major trip types. In addition, user demand exploration to identify design opportunities was measured through experience prototyping and self-report measures methods. The results of this study provide priority activities, desired mood, and user needs for three major trip types and suggest four specific design opportunities to consider when designing SAVs.

6.1. Design implications

The overall results of this study indicate that user needs vary by trip type. Therefore, it seems that meeting user needs will require context-specific flexible design, taking into account such things as future SAV passengers' travel objectives, individual or group boarding. In addition, for users, system information such as the current location of the SAV and the time remaining until arrival is a factor that improves in-vehicle activity experience. Furthermore, users wanted to use shared space amenities as individuals and expect that features that support their activities overall during travel time will stimulate positive cognition of SAVs as a role to assist individuals' experiences.

The most important thing about the user experience was the invasion of personal privacy. Shared spaces, face-to-face structures, and interior design without individual boundaries have caused this problem, and this point seems to be a must-have to be solved.

6.2. Limitation and future study

Although the current study has provided meaningful findings, this study has some limitations: First, the data is less reliable due to the small number of samples in user experiments using experience prototyping methods. Second, because the participants were all people of Korean nationality, I failed to consider all racial and cultural diversity in the experimental stage. Third, this experiment explores the unexpected future in a qualitative method. Therefore, there is a lack of objectivity to the result of user activity.

6.3. Expected contributions

Overall research can contribute to the design development of automakers and interior, product, and service designers developing SAVs. In order for future passengers to participate in various types of activities at SAVs, amenities, devices, structures, and services that can be used to meet their needs will need to be rethinking. The activity priorities and needs proposed in this work and four specific design results can contribute to these design development areas. Furthermore, if design development related to SAV services and systems continues, this can lead to better awareness of SAV and improved user experience, leading to future mobility for SAVs that provide many benefits.

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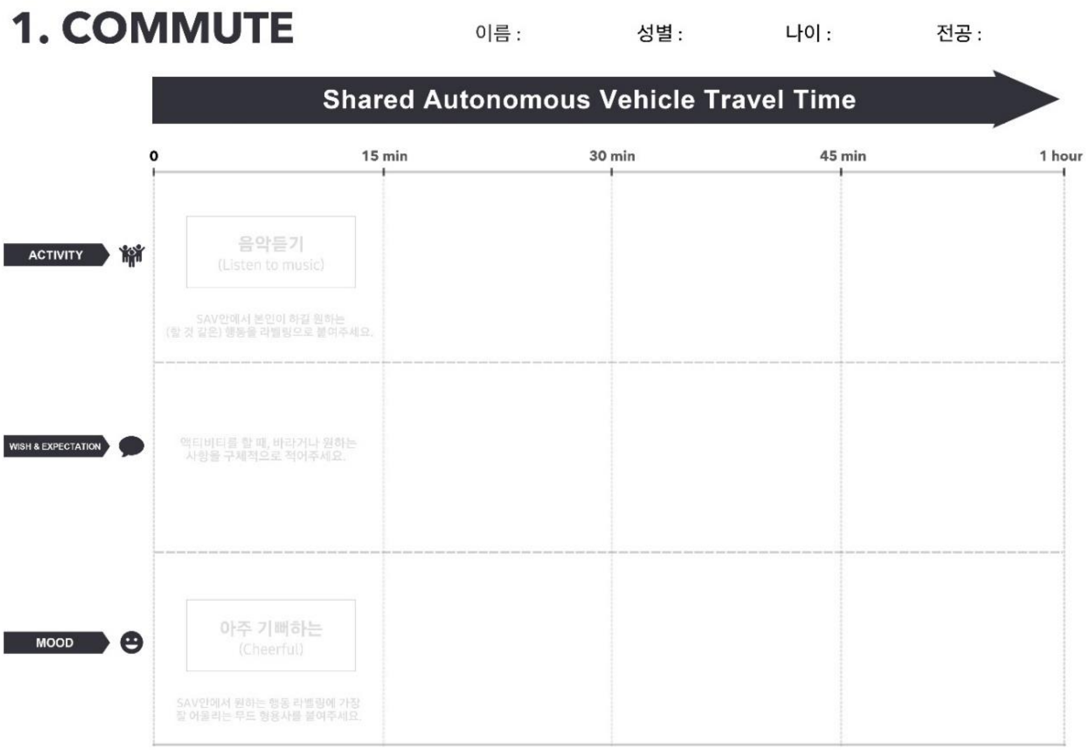
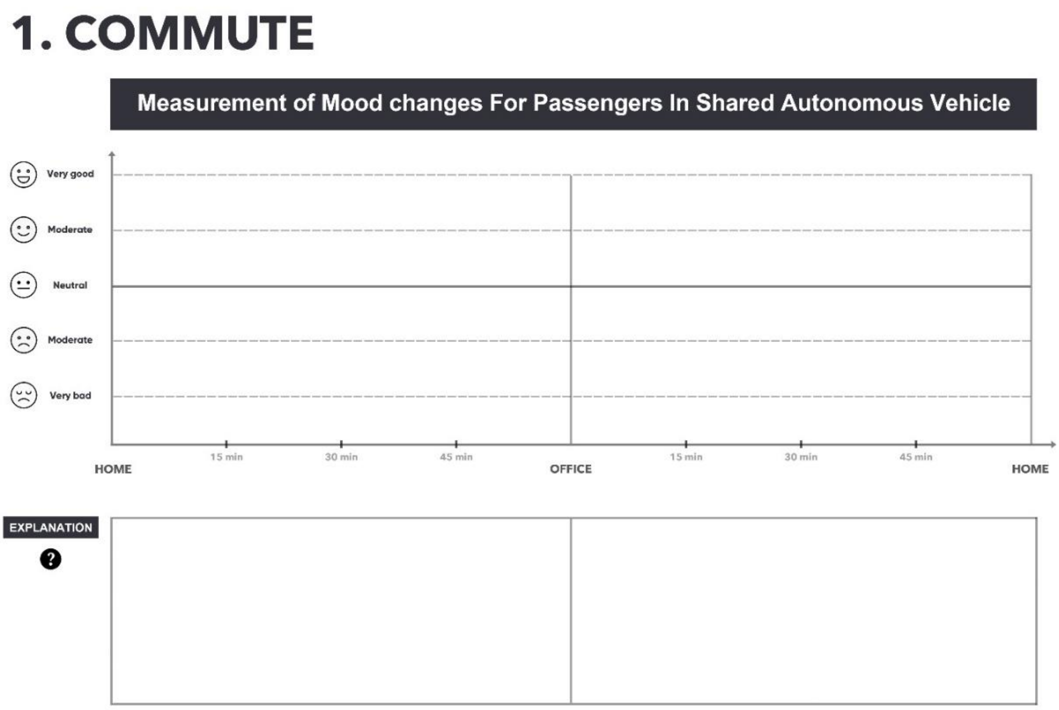
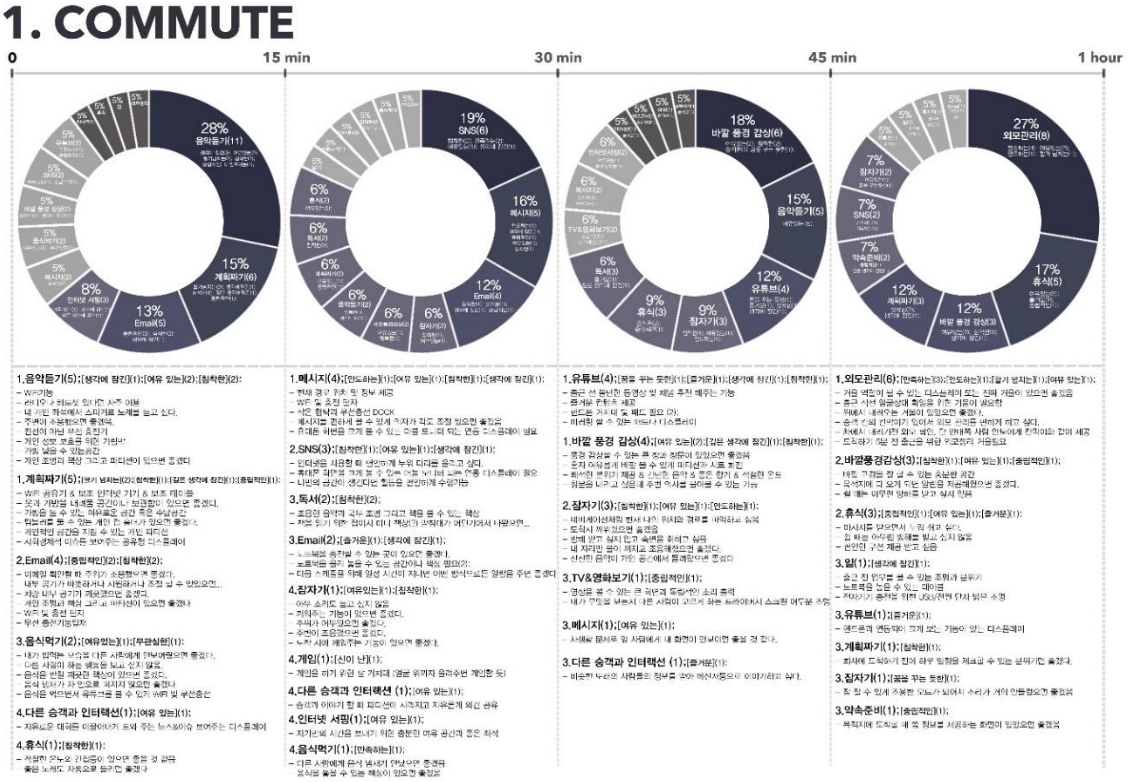
APPENDICES

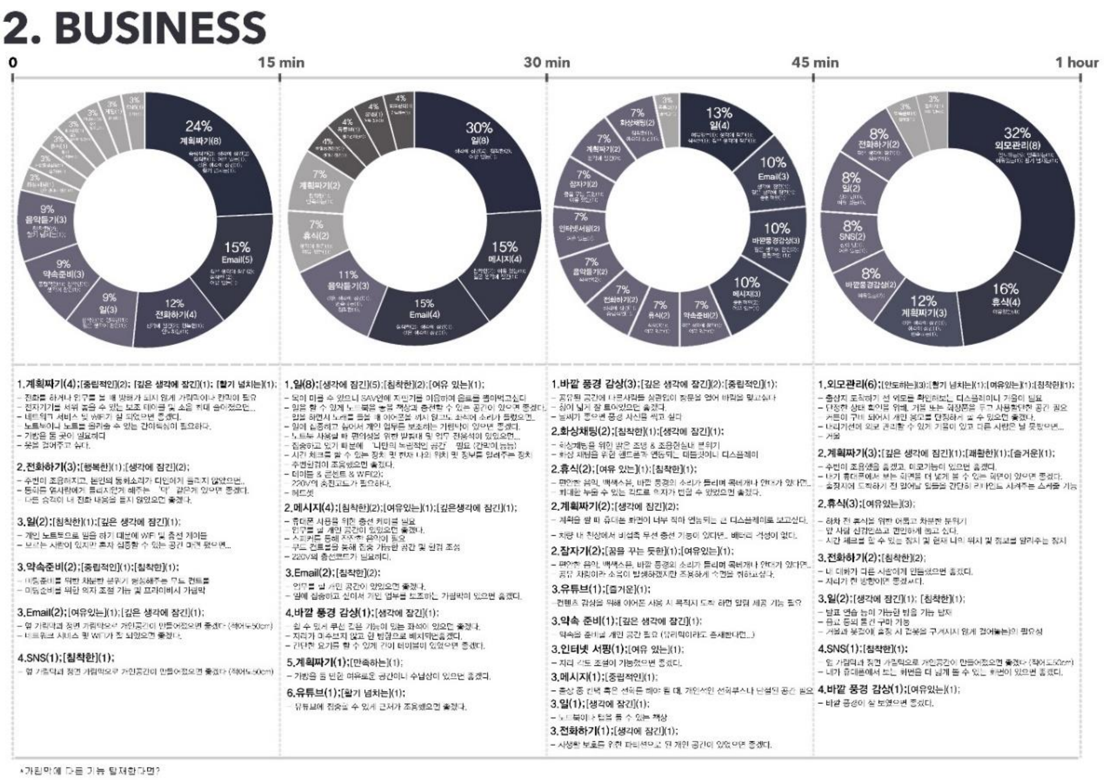
Appendix 1 – Self report measure materials



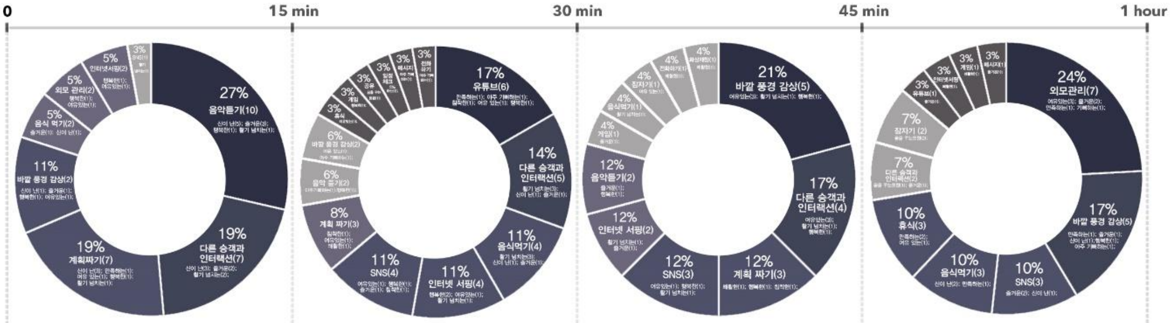


Appendix 2 – Data analysis of self-report measure





3. LEISURE



1.음악듣기(3);[신이 난](2);[활기 넘치는](1);
- 방음 기능
- 여행 중 시원한 맥주를 마실 수 있는 냉장고
- 블루투스 스피커를 통해 좋아하는 음악을 크게 틀고 승객과 공유
- 개인 좌석에서 이어폰을 끼지 않고 스피커로 듣고 싶음

1.다른 승객과 인터랙션 (3);[활기 넘치는](1);[즐거운](2);
- 식당 놀이시설 등 다른 승객들과 소통하는 컨텐츠가 공유
- 여행을 위한 짐들을 보관하는 가방 보관대가 필요함.
- 다른 승객과 무언가를 같이 먹고 할 수 있는 공용 테이블
- 커뮤니케이션을 위해 동승자들과 함께 사용할 수 있는 테이블
- 옆 사람이 불편하지 않게 개인 짐을 보관할 수 있었으면 좋겠음

2.계획짜기(2);[행복한](1);[신이 난](1);
- WIFI
- 짐을 넣을 수 있는 트렁크와 여분의 공간 필요

2.바깥 풍경 감상(2);[여유 있는](1);[신이 난](1);
- 바깥 풍경 감상을 위한 넓은 창이
- 창문이 투명하고 눈 높이에 창문이 있어서 바람을 쐴 수 있으면 좋겠다.

3.음식먹기(1);[신이 난](1);
- 내 의자 옆 짐칸이 있어서 불편하지 않게 물건을 꺼내고 넣고 싶음

1.음식먹기(4);[행복한](1);[만족하는](1);[즐거운](1);[활기 넘치는](1);
- 식사를 위한 테이블과 냄새가 다른 승객에게 퍼지지 않는 냄새 배출 기능
- 음식을 자유롭게 먹어도 환기가 잘되어서 냄새를 신경 안썼으면 좋겠다.
- 음식을 먹기 위한 테이블이 있으면 좋겠다 (사용 안할 땐 숨겨지는 기능)
- 음식을 먹을 수 있는 테이블

2.유튜브(3);[만족하는](1);[아주 기뻐하는](1);[행복한](1);
- 유튜브 시청을 위한 휴대폰 거치대와 충전기가 필요함.
- 무선 충전 기능과 화면 확대기 스크린 변경 기능 필요
- 주위가 조용했으면 좋겠다.

3.인터넷 서핑 (2);[행복한](2);[활기 넘치는](1);
- WIFI 기능
- 무선 충전 기능과 화면 확대기 스크린 변경 기능 필요
- 자신의 휴대폰에서 보는 것을 다른 사람에게 쉽게 공유했으면 좋겠다.
- 코레일처럼 맛집이나 가볼 곳을 자동으로 추천해주는 컨텐츠 기능

3.계획짜기(2);[침착한](1);[여유 있는](1);
- 메모기능이 있으면 좋겠다.
- 노트북 또는 태블릿을 충전할 수 있는 콘센트와 거치대 필요

4.다른 승객과 인터랙션 (1);[활기 넘치는](1);
- 비슷한 목적지에 승객들이니까 큰 디스플레이가 있어서 루트와 정보 공유
- 공유한 내용을 포스트잇이나 메모를 할 수 있는 기능이 있으면 좋겠다.

1.다른 승객과 인터랙션 (3);[즐거운](2);[활기 넘치는](1);
- 같이 정보나 컨텐츠를 공유할 수 있는 디스플레이가 있었으면 좋겠다.
- 다같이 무언가를 띄워서 볼 수 있는 큰 화면이 있으면 좋겠다.
- 편안하게 다른 승객과 대화할 수 있는 분위기 및 쾌적한 환경

1.바깥 풍경 감상(3);[여유 있는](2);[행복한](1);[활기 넘치는](1);
- 큰 창이 있으면 좋겠음 (2);
- 천장이 뚫려 있으면 좋겠음
- 목적지까지 남은 거리와 시간 등 정보를 제공해줬으면 좋겠음
- 현재 어느 위치에 있는지를 알려주는 정보 기능의 디스플레이
- 바깥 풍경을 보면서 트는 노래가 차량 안에 큰 블루투스 스피커로 출력

2.계획짜기(2);[쾌활한](1);[행복한](1);
- 여행 계획을 위한 편안한 자세와 즐거운 음악 밝은 조명 기능 필요
- 창가 쪽에 연동되는 디스플레이가 위치해서 웹서핑을할 수 있으면 좋겠다.

3.전화하기(1);[쾌활한](1);
- 앞.옆 사람과 구분될 수 있는 공간 분리대(전화 시 주변 사람들이 신경쓰임)

4.게임(1);[즐거운](1);
- 각 자리마다 모바일 기기(태블릿PC)가 있으면 좋겠다.

5.SNS(1);[여유 있는](1);
- 내 화면이 주변 사람에게 안보였으면 좋겠다.

6.잠자기(1);[꿈을 꾸는 듯한](1);
- 다른 사람들이 자고 있는 나를 보지 못했으면 좋겠다.
- 주위가 조용했으면 좋겠다.
- 도착지에 도착하면 깨워주는 기능이 있으면 좋겠다.

1.외모관리(4);[즐거운](1);[여유 있는](2);[만족하는](1);
- 하차 전 거울을 통해 현재 외모 상태를 보고 싶다. (3);
- 접이식 거울이 있어서 상태를 체크해보고 싶다.
- 다른 승객이 내가 화장하는것을 안봤으면 좋겠음.

2.음식먹기(2);[신이 난](2);
- 같이 먹을 것을 공유할 수 있는 책상이 필요함.
- 간이 편의점, 자판기가 있었으면좋겠다.

3.유튜브(1);[즐거운](1);
- 내 화면이 주변 사람에게 안보였으면 좋겠다.
- 주변이 조용했으면 좋겠다.
- 도착지에 도착하면 진동같은 알림을 제공해주는 기능 필요

4.바깥 풍경 감상(1);[아주 기뻐하는](1);
- 여행 목적이라면 차의 모든 부분이 통유리로 되어 있으면 좋겠다.

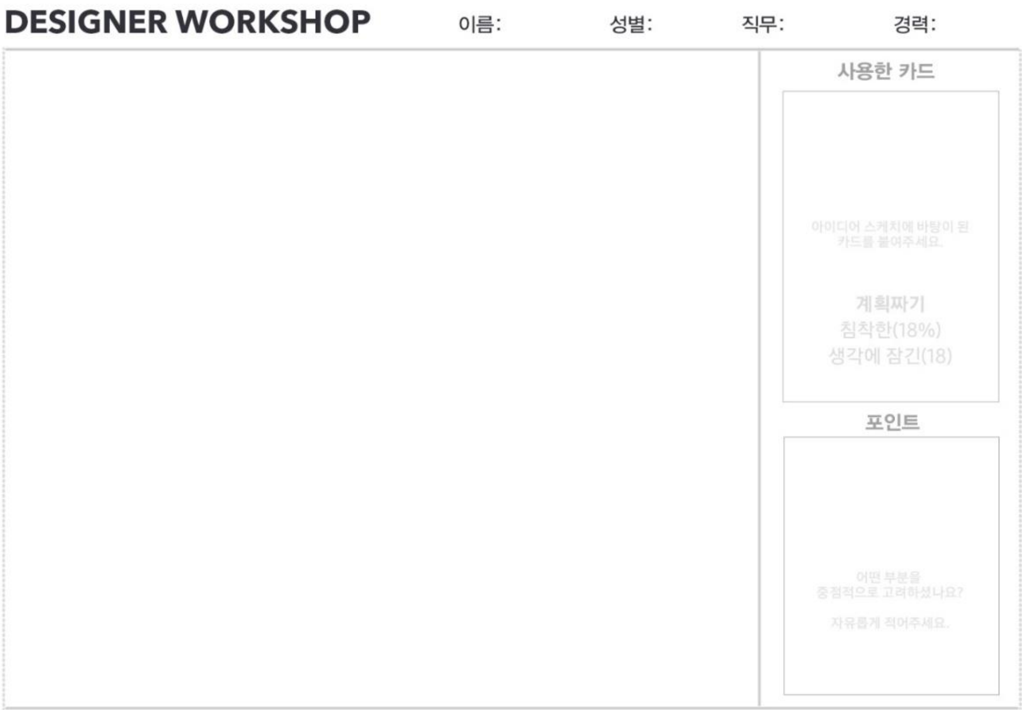
5.소셜네트워크(1);[즐거운](1);
- 음악 추천 시스템, 음악을 편하게 틀 수 있는 태블릿

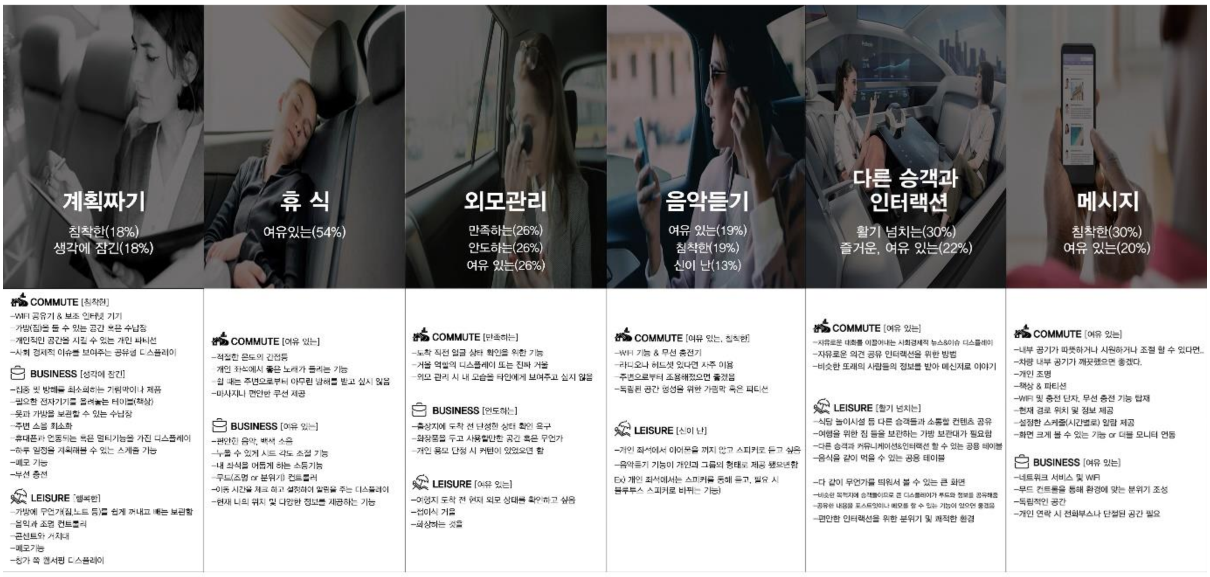
6.잠자기(1);[꿈을 꾸는 듯한](1);
- 수면을 위한 다리 받침대와 등받이 필요함
- 개인공간의 조명이 있고 어둡게 할 수 있는 컨트롤
- 소음 제어
- 냉온방 기능

*가림막에 다른 기능 탑재한다면?

*무선 충전 테이블이 하이드됐다가 제공 된다면?

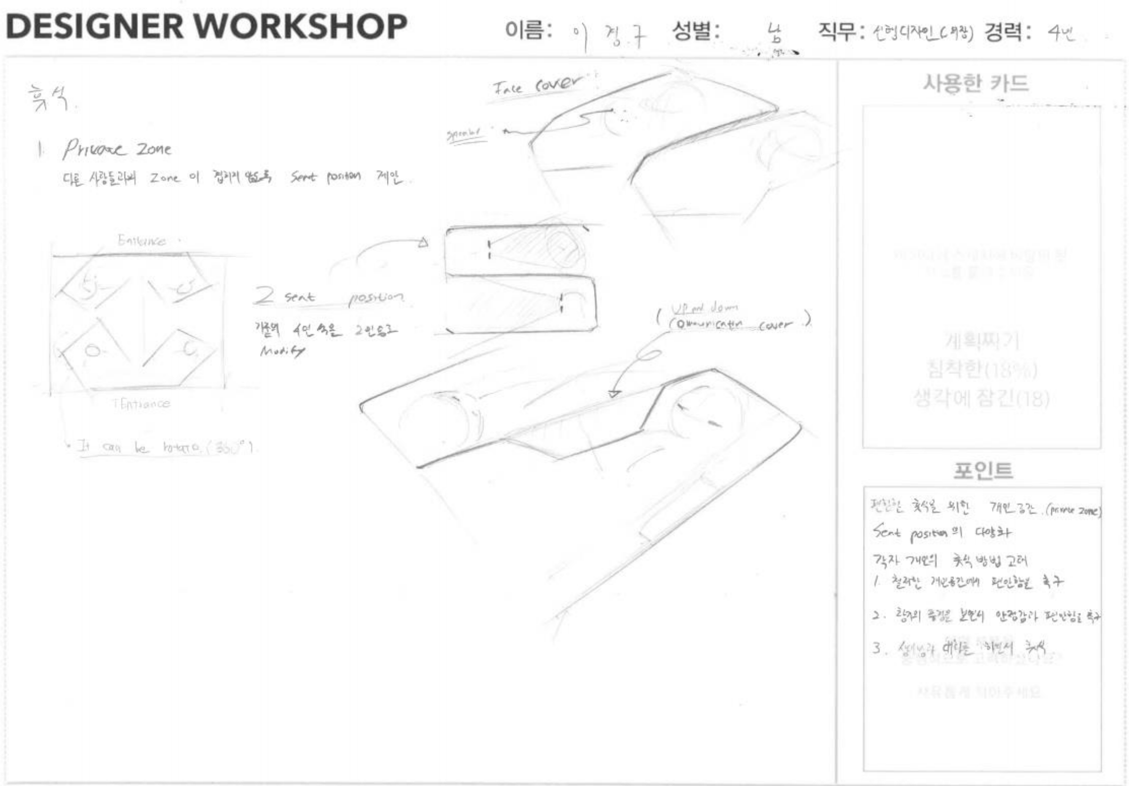
Appendix 3 – Designer workshop materials: handouts, card, image mood board

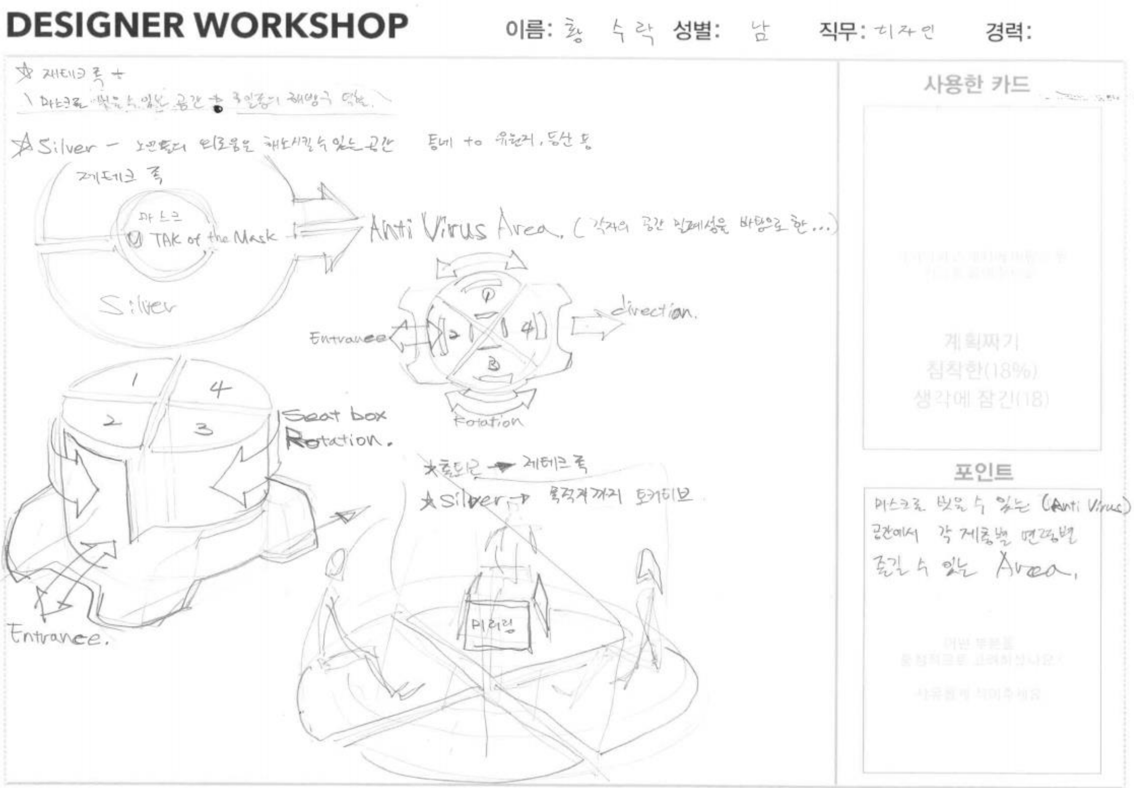





Profitability
Growth
23 %
Anna
Hello Anna
BOSCH
7:29
Tuesday 27
Alarm 7:30AM

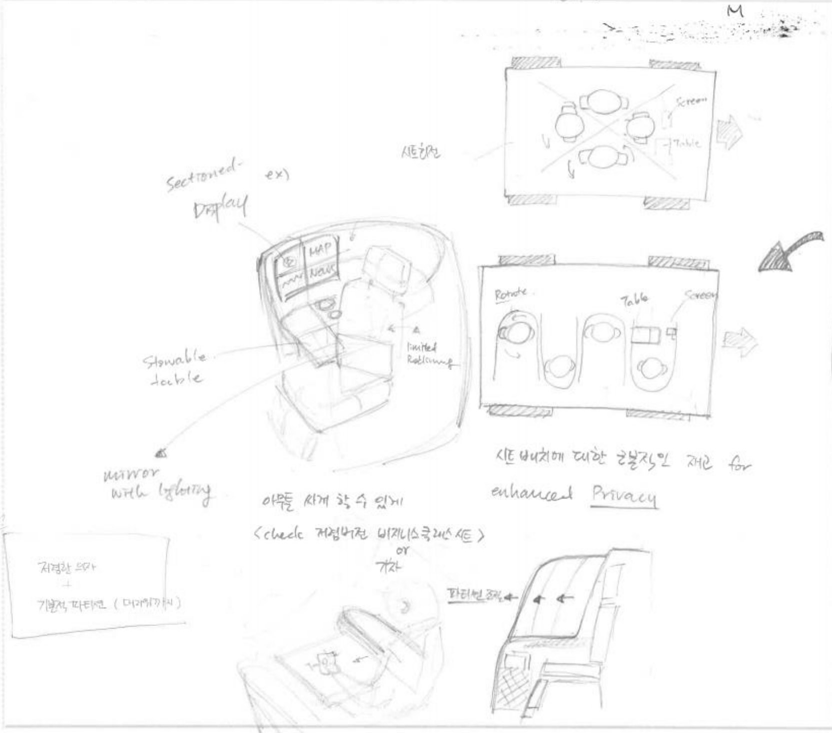
Appendix 4 – Result of pilot test





DESIGNER WORKSHOP

이름: 전재용 성별: M 직무: 선행디자인 경력: 7



사용한 카드

휴식

- 쉴때 주변으로부터 아무런 방해를 받고 싶지않음
- 이동시간 체크할 설정하며 여정을 주는 Display
- 현재 나의 위치 및 다양한 정보를 제공하는 기능

⊕

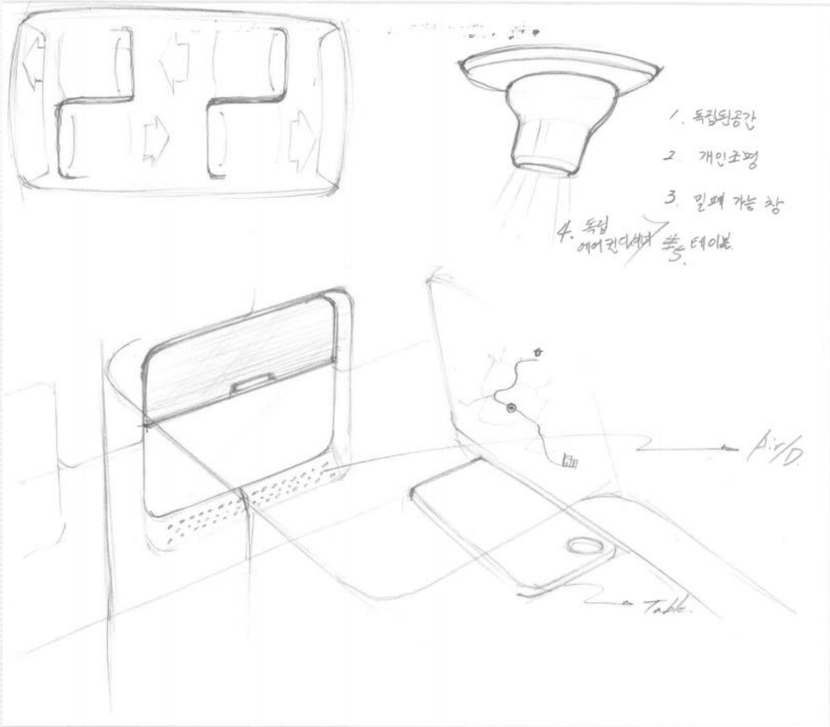
외관관리

- 상태확인 거울 or Display
- 타인에게 보여주고 싶지않음
- 화장품은 두고 사용할만한 공간
- 커텐
  etc.

포인트

DESIGNER WORKSHOP

이름: 성별: 남 직무: 디자인 경력: 17년



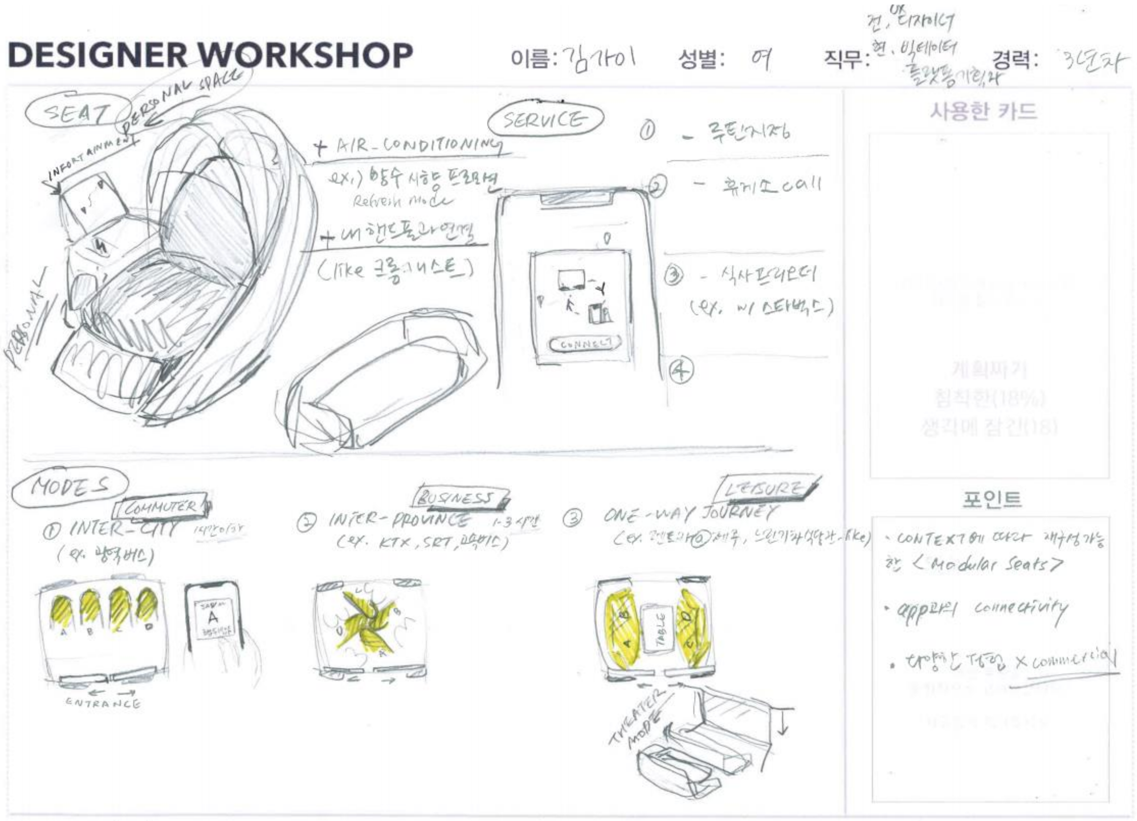
사용한 카드

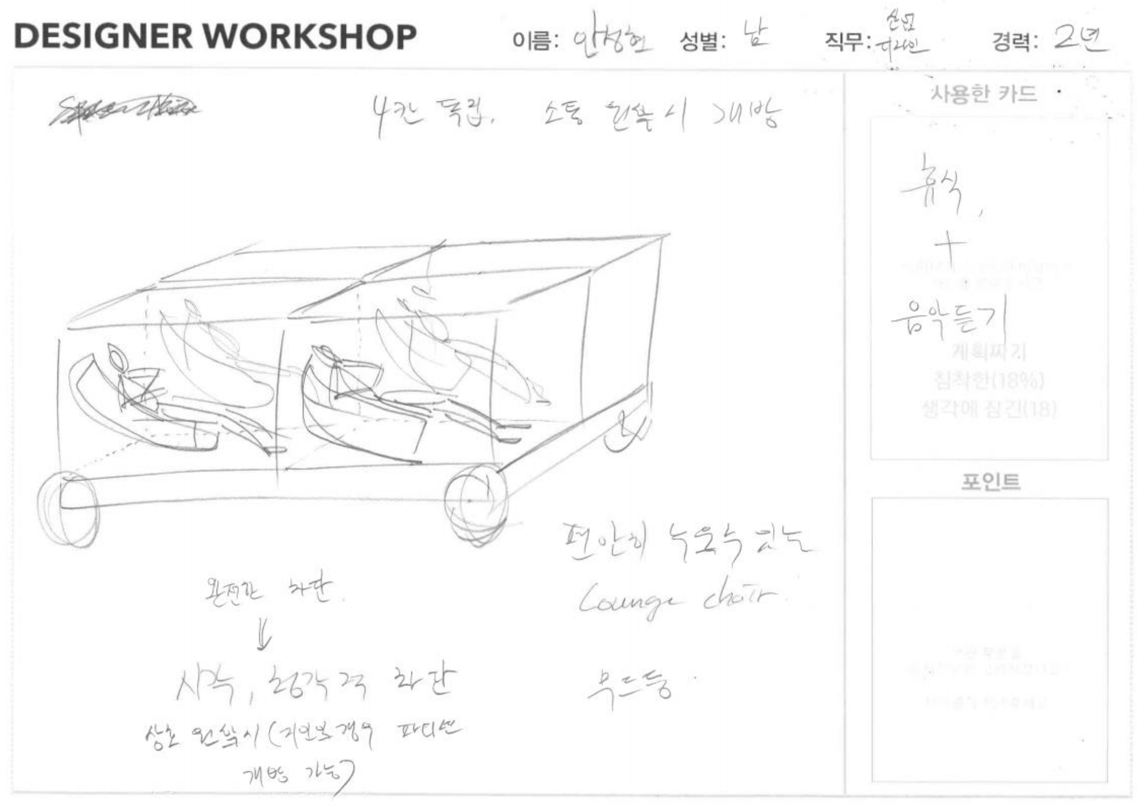
계획짜기
침착한(18%)
생각에 잠긴(18)

포인트

- 적절한 온도 간접등.
- 쉴 때는 주변으로부터 아무런 방해를 받고 쉬기 싫음
- 현재 나의위치

Appendix 5 – Result of designer workshop





DESIGNER WORKSHOP

이름: 안성현　성별: 남　직무: 산업 디자인　경력: 2년

사용한 카드

버지니
+
휴식

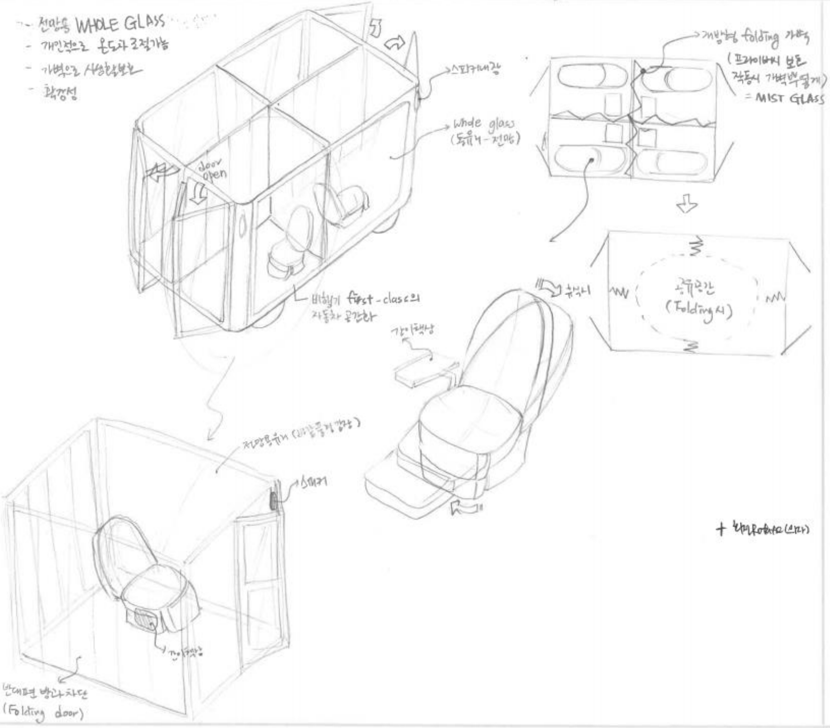
계획짜기
침착한(18%)
생각에 잠긴(18)

포인트

독립적인 공간
파티션
더블 모니터

DESIGNER WORKSHOP

이름: 전성은　성별: 여자　직무: 제품디자이너　경력: 8년차



사용한 카드

계획짜기
침착한(18%)
생각에 잠긴(18)

포인트

- 쉴때 주변으로부터 아무런 방해를 받고 싶지 않음 → SAV 안에서도
- 주변으로부터 조용해졌으면 좋겠음
- 독립된 공간, 파티션이 있지만 용도에 따라 확장이 가능하게 한다.
- 여행, 퇴근, 출장 등 같힌 공간이 아닌 개방감을 주기에 언제든지 전망을 볼수 있고, 원치 않을 때는 MIST glass 사용해서 외부와 차단가능

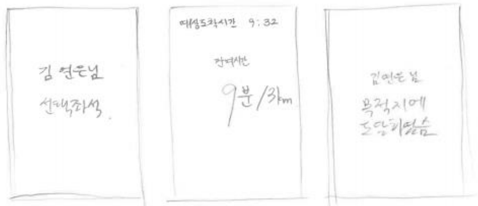
DESIGNER WORKSHOP

이름: 김연우 성별: 여 직무: 개발자 경력: 2년

1. 승차시
- 좌석표시 (승차시 해당 좌석 디스플레이에 표시)
- 좌석 선택은 콜링 시에 앱에서 선택 가능하겠죠?

2. 운행중
- 목적지 도착시간 / 거리 표시
  예상 도착시간
  → 굳이 앱을 들여다보지 않아도, 그냥 눈뜨면 딱 보이게
- 긴급상황 발생시 긴급하차 등의 긴급호출.
  긴급하차.
- 경로 변경 등의 이동 중 발생하는 이슈? → 차안 폰에서 해결

3. 하차 시.
- 하차정보 및 결제내역



사용한 카드

계획짜기
침착한(18%)
생각에 잠긴(18)

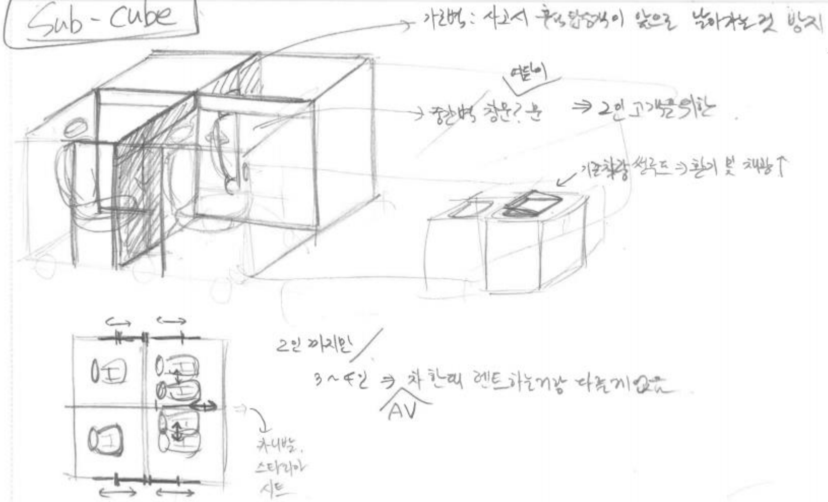
포인트

휴식. 저는 조용하고 생각하기 위해서 평소 대중교통을 이용할 때 수시로 현재 위치를 체크하고, 도착시간 전에 알람을 설정해놓습니다. 자율은 위치와 편하게 휴식을 취할 수 있도록 해주는 간단한… 서비스·디스플레이 아이디어입니당.

DESIGNER WORKSHOP

이름: 이승아 성별: 남 직무: 기획 UI/UX 경력: 창업 2년차

Sub-cube



- 디스플레이나 보가요소들은 당연히 많이 있으면 좋으므로 별도로 언급X, 공간에 대해서만 고민

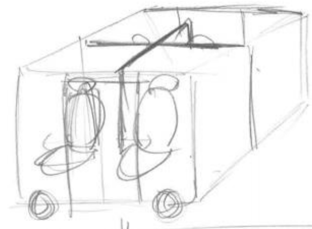
장점
- 개별난방, 개별환기, 완벽한 프라이버시,
- 2인까지 공간 공유 가능 : 연인, 친구, 출장동료 소통가능

사용한 카드

계획짜기
침착한(18%)
생각에 잠긴(18)

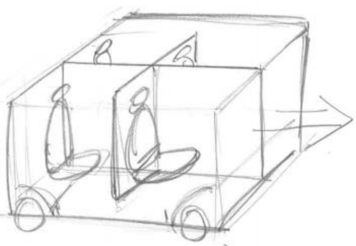
포인트

DESIGNER WORKSHOP 이름: 이승일 성별: 남 직무: 기획/UI/UX 경력: 재직2년차



운전석으로 2인석 바라보게,
절반 공간 분리로 프라이버시 ↑
가운데 가림막으로 프라이버시 ↑

단점, 사고시 위험함 ↑



절반 칸막이 ⇒ 프라이버시 ↑
이상한 사람 만날 확률 ↓
범죄 위험 ↓
냄새/오염 확률 ↓

사용한 카드

휴식 / ~~[illegible]~~

계획짜기
침착한(18%)
생각에 잠긴(18)

포인트

지하철 / 비행기 / 버스 / KTX 등
대중교통 사용환경/이유와 동일하거나
유사한 상황

출퇴근시 → 1인
여행/출장 → 2인 ~ 이상
프라이버시, 와식/환기

ACKNOWLEDGEMENT

It's been two years since I came to the UNIST. I thought a lot before coming to graduate school. The design of creating something out of nothing is meaningful in itself, but I wanted to study how to produce results optimized for users. In that sense, this thesis is a significant result representing my two years of growth.

Firstly, I am grateful to my parents for their full support so that I can study design. Whenever I was having a hard time or happy, they always trusted and supported me. For me, they are the driving force and reason for my life. I love you very much.

I want to thank Professor Chajoong Kim for helping me do good research at UNIST. I was able to learn a lot of motivation and life lessons through you. Thank you for allowing me to experience research in a good environment.

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